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1.0		2.8	2.5
1.1		3.2	2.2
		3.6	2.0
		4.0	1.8
1.25	1.4		1.6

UTION TEST CHART

(4)

Naval Environmental Prediction Research Facility
Monterey, CA 93943-5006

Technical Report TR 87-04 December 1987

TEMPERATURE PROFILE CONSTRUCTION METHODS: AN EVALUATION

AD-A195 919

William T. Thompson
Naval Environmental Prediction Research Facility

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A method for obtaining atmospheric temperature profiles in data sparse areas is to extract temperature from numerical weather prediction model analysis fields at mandatory levels. An important component of this technique is the near surface air temperature, which can be obtained either from the numerical model's extrapolated mean planetary boundary layer temperature or from an analysis of the observations. In an effort to determine which of these two values gives the most representative profile, comparisons were made between profiles constructed from Fleet Numerical Oceanography Center (FNOC) fields and ship soundings from weather station ships in the North Atlantic. Although both profiles compared favorably to the soundings in many cases, the analysis field provided more representative estimates of atmospheric stability than the model-derived near surface air temperature

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1. INTRODUCTION

This report evaluates two different methods for construction of vertical temperature profiles from analysis fields of numerical weather prediction models. The two methods differ in the specification of the near-surface air temperature. The results of this evaluation will be of interest to persons responsible for other models requiring input of vertical temperature profiles.

Vertical temperature profiles are required input for several of the programs producing numerical environmental products at Fleet Numerical Oceanography Center (FNOC). Observations of vertical temperature profiles, however, are rarely available over open ocean areas. Ship observations are sparse and satellite-derived profiles lack sufficient vertical resolution and accuracy near the surface. An alternative method involves extracting temperature values from numerical weather prediction (NWP) model analysis fields at standard levels (surface, 1000 mb, 925 mb, 850 mb, 700 mb, 500 mb) at the point of interest, but this method likewise provides relatively poor vertical resolution. An important aspect of this method is the "near surface air" temperature which, together with the sea surface temperature, determines the air-sea temperature difference. Air-sea temperature difference determines atmospheric stability.

There are two sources of "near surface air" temperature at FNOC. One is from the NWP model boundary layer - the mean boundary layer temperature is adjusted dry adiabatically to the surface. The field produced in this manner is stored in FNOC

record A07. The second source is from an analysis of the surface observations. This field is stored in record A10. Soundings can be constructed using either field. It is of some importance, then, to determine which field, when combined with the other model standard levels, will provide the most representative sounding.

2. METHODOLOGY

In an effort to address this problem, a series of comparisons were made between ship soundings constructed from the mandatory level, significant level, and surface report files of the operational data base, and "pseudo-soundings" constructed from the sea surface, "near surface air", 925 mb, 850 mb, 700 mb, and 500 mb temperature fields interpolated to the ship location. Two pseudo-soundings were produced in each case, one using the model derived A07 field and one using the analyzed A10 field. All three soundings were plotted together in order to facilitate comparison.

The cases are summarized in Table 1 and the plots are shown in Figures 1-50. The locations of the weather station ships used in the evaluation are shown in Figure 51. In Table 1, the cases are categorized in terms of the ship used, the date time group, which pseudo-sounding was most representative of the ship sounding, and whether the boundary layer was stably or unstably stratified (based on the observed air-sea temperature difference). In Figures 1-50, the actual ship sounding data

Table 1. Summary of cases used in Evaluation

Case No.	Ship/Time	A07/A10	Stable/Unstable
1	CHAR 86050500	A10	U (A07 N)
2	MIKE 86050700	A10	U (A07 S)
3	MIKE 86051500	tie	U
4	LIMA 86051500	A10	U (A07 S)
5	CHAR 86051500	tie	S
6	MIKE 86051512	tie	U
7	LIMA 86051512	tie	U
8	CHAR 86051512	tie	U
9	CHAR 86052012	tie	U
10	LIMA 86052012	A07	U
11	MIKE 86052012	tie	U
12	LIMA 86052000	A07	U (A10 S)
13	CHAR 86052000	tie	S
14	MIKE 86052000	tie	S (A07,A10 U)
15	CHAR 86060312	A10	S
16	MIKE 86061212	A10	U
17	CHAR 86061212	tie	S (A07,A10 U)
18	MIKE 86062612	A07	N (A10 U)
19	LIMA 86062612	A10	U (A07 N)
20	CHAR 86062612	tie	S (A07,A10 U)
21	MIKE 86061512	A10	S
22	CHAR 86061512	tie	U
23	LIMA 86061512	A10	U (A07 S)
24	CHAR 86070112	A10	S (A07 U)
25	MIKE 86070112	tie	U (A07,A10 S)
26	MIKE 86071712	A10	U (A07 S)
27	CHAR 86071600	A10	U
28	LIMA 86071600	tie	U
29	LIMA 86071612	tie	U
30	MIKE 86071600	A10	S
31	MIKE 86071612	tie	S (A10 N,A07 U)
32	CHAR 86071712	A10	S (A07 S)
33	LIMA 86071712	A10	U
34	CHAR 87010800	A10	S (A07 U)
35	MIKE 87010800	tie	U
36	MIKE 87010700	tie	U
37	LIMA 87010700	A10	U (A07 S)
38	CHAR 87013012	tie	S
39	MIKE 87013012	A07	U
40	LIMA 87013012	tie	U
41	MIKE 87013100	A07	U
42	CHAR 87013100	A07	U
43	MIKE 87013100	A07	U
44	CHAR 87013100	tie	S
45	LIMA 87013100	tie	U
46	MIKE 87020212	tie	U
47	MIKE 87020212	tie	U
48	CHAR 87020212	tie	U
49	CHAR 87020512	tie	U
50	MIKE 87020512	A10	U

points are marked with "X" so that the air-sea temperature
difference can be seen easily. The determination as to which
pseudo-sounding was most representative was based not only on a
subjective comparison to the ship sounding but also on stability;
if the pseudo-sounding appearing most like the ship sounding had
an air-sea temperature difference of opposite sign (as compared
to the ship sounding), the other pseudo-sounding was declared
the "winner". Similarly, if both pseudo-soundings had air-sea
temperature difference opposite in sign to the ship sounding, the
case was declared a "tie". A tie was also declared when neither
pseudo-sounding offered a clearly superior representation of the
ship sounding, i.e., when both were equally bad or good.

3.   RESULTS

Examination of Figures 1-50 shows clearly that, in most
cases, the pseudo-soundings provide a very close approximation to
the ship sounding. There are, of course, some exceptions to this
general rule; for example, the pseudo-soundings in cases 6, 9,
15, 22, and 35 are not particularly representative of the ship
soundings. Case 15 in particular is striking; this case is ship
CHARLIE at 12Z on 3 June 1986. Apparently, a strong warm frontal
passage occurred just prior to 12Z, causing an extremely stable
boundary layer to develop. The CHARLIE observation was obviously
not accepted by either the analysis or the model initialization.

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Another feature which becomes evident on examination of the Figures is that often there is disagreement between the soundings as to the atmospheric stability. There are, in fact, 17 cases in which disagreement is present. A good example is case 24 for ship CHARLIE at 12Z on 1 July 1986. In this case, both the sounding and the A10 pseudo-sounding are stable while the A07 pseudo-sounding is stable near the surface and strongly unstable just above. Many of these cases involve large near-surface lapse rates in one sounding or another. In the vast majority of these cases (13 of the 17), the A10 pseudo-sounding is the "winner".

In many of the winter cases (cases 34-50), the magnitude of the air-sea temperature differences is quite large with the sea generally much warmer than the air. Only about 18% of the winter cases are stable. This is not surprising given the severity of North Atlantic winters.

In Table 2, the number of "wins" for A07 (i.e., the number of cases in which the pseudo-sounding was constructed using the model-derived near surface air temperature) and the number of "wins" for A10 (number of cases in which the pseudo-sounding was constructed using the analyzed near surface air temperature) are tabulated, along with the number of ties. The data are also stratified in terms of stability with a fourth category (labeled "conflict") for cases in which the soundings disagreed on the sign of the air/sea temperature difference. More than half of the cases are tied. There are also more ties than wins in each

Table 2. Stability Stratification: Total

	total	A10	A07	tie
total	50	16	7	27
stable	14	6	0	8
unstable	35	10	6	19
neutral	1	0	1	0
conflict	17	13	2	2

stability category except neutral and conflict. In cases in which there is a winner, A10 wins more than twice as frequently as A07 (16 vs. 7) and A10 wins more frequently in each stability category (except neutral) as well. A10 wins most decisively in the conflict category. Finally, it should be noted that the vast majority of the cases (35) are unstable.

In an effort to identify biases in the data, several different stratifications were employed. Table 3 is identical to Table 2 except that only the 33 summer cases are included. The same general trends are apparent in the summer, including the overwhelming number of wins for A10 in the conflict situations (11 out of 15).

Table 3. Stability Stratification: Summer

	total	A10	A07	tie
total	33	13	3	17
stable	11	5	0	6
unstable	21	9	2	10
neutral	1	0	1	0
conflict	15	11	2	2

Table 4 includes only winter cases. In the winter, A07 is slightly superior to A10 (by one case). This is probably due to the fact that the stronger synoptic forcing in the winter cases brings the model initialization closer to the actual situation. Note also that there are only two conflict cases. This is the result of the large air-sea temperature differences due to the cold air associated with North Atlantic storms removing any ambiguity as to the atmospheric stability. In winter as in summer, most of the cases are unstable (82%). In both of the conflict cases, A10 is the winner.

Table 4.   Stability Stratification: Winter

	total	A10	A07	tie
total	17	3	4	10
stable	3	1	0	2
unstable	14	2	4	8
neutral	0	0	0	0
conflict	2	2	0	0

Tables 5 and 6 are for the day and night cases, respectively. The weather station ships are between one hour ahead (MIKE) and two hours behind (CHARLIE) Greenwich Mean Time (ZULU Time), so that 12Z and 00Z can be used to distinguish night from day. There are no particularly striking diurnal differences, although there is a higher percentage of stable cases at night (35% at night vs 16% during the day). Ties predominate in all categories (except

Table 5.   Stability Stratification: Day

	total	A10	A07	tie
total	30	10	3	17
stable	5	1	0	4
unstable	24	9	2	13
neutral	1	0	1	0
conflict	10	5	1	4

Table 6.   Stability Stratification: Night

	total	A10	A07	tie
total	20	7	4	9
stable	7	2	0	5
unstable	13	5	3	5
neutral	0	0	0	0
conflict	7	5	1	1

neutral and conflict) and A10 is substantially ahead in cases in
which there is a winner. In the conflict situations, the
percentage of ties during the day is somewhat higher and A10 wins
in only half of the total. During the night, A10 is clearly
superior in the conflict situations.

5.   CONCLUSIONS

In examining the results described in the preceding section,
note that all of the cases were based on data from the North
Atlantic ocean and the conclusions may not apply to other ocean
basins. The necessity of having a ship sounding for verification

required that a weather station ship be used; all of the weather station ships still in operation are located in the North Atlantic ocean. The variety of day/night and summer/winter cases sampled may allow generalization to other geographical areas. In spite of the relatively large number of cases sampled and the number of different stratifications employed, no clear biases became apparent. In most of the cases, neither sounding was clearly superior to the other. In most of those cases that had a winner, A10 was the winner.

The predominance of ties in cases sampled might at first seem to make it impossible to determine which field should be used to construct soundings. On closer inspection, however, it becomes apparent that A10 gives superior results in cases in which the soundings disagree on the sign of the air-sea temperature difference. Correct diagnosis of atmospheric stability is extremely important for a variety of applications. It is recommended, therefore, that the A10 field (the analyzed field) be used in the construction of pseudo-soundings.
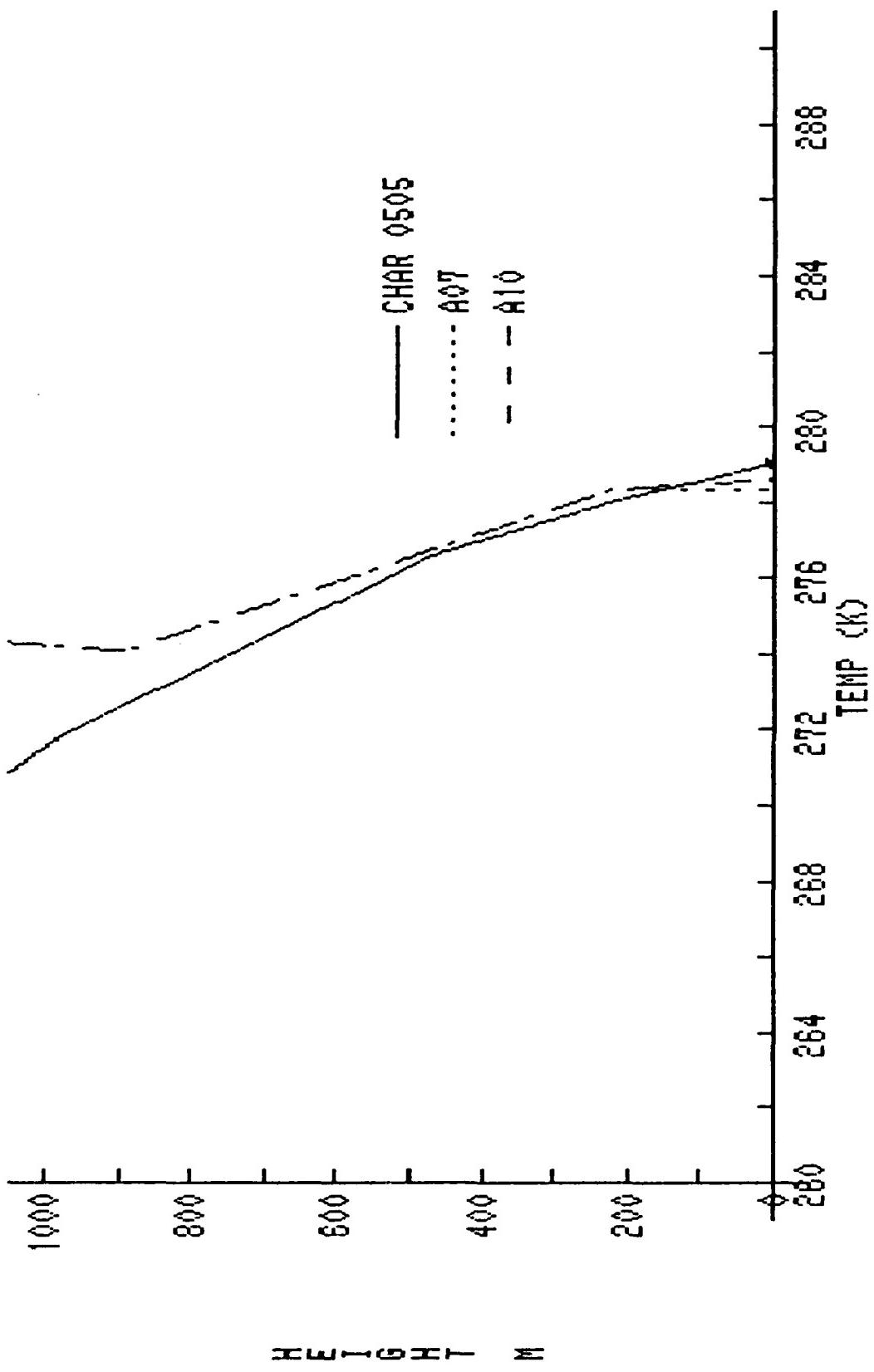
Figure 1. Comparison of soundings constructed using fields A07 and A10 with a ship sounding from weather station ship Charlie at 00Z 5 May 1986. The ship sounding is depicted as a solid line, the A07 sounding as a dotted line, and the A10 sounding as a dashed line; individual ship sounding data points are indicated by X (line & point coding applies likewise to Figures 2-50).
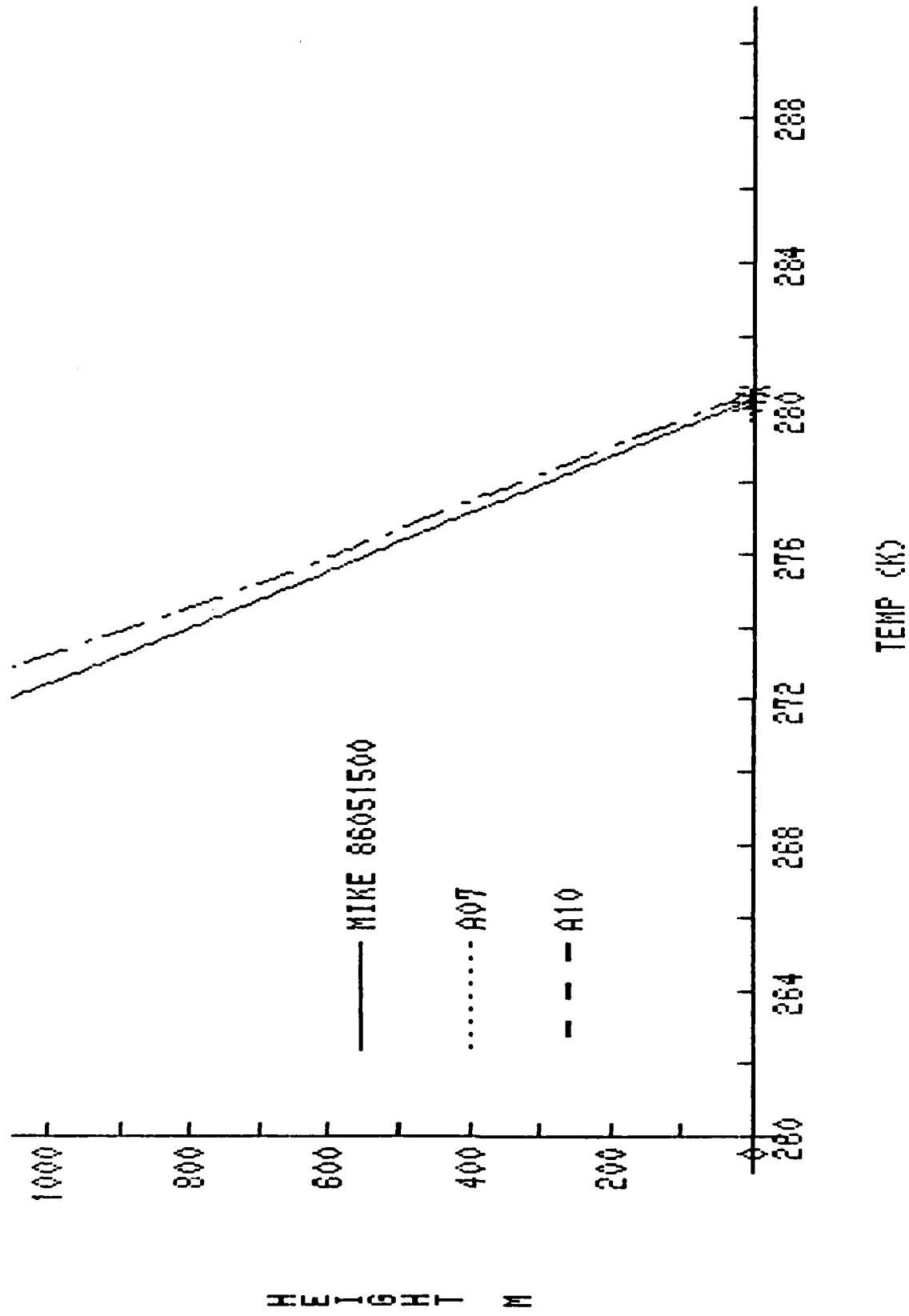
Figure 2. As in Fig. 1, for ship Mike 00Z 7 May 1986.
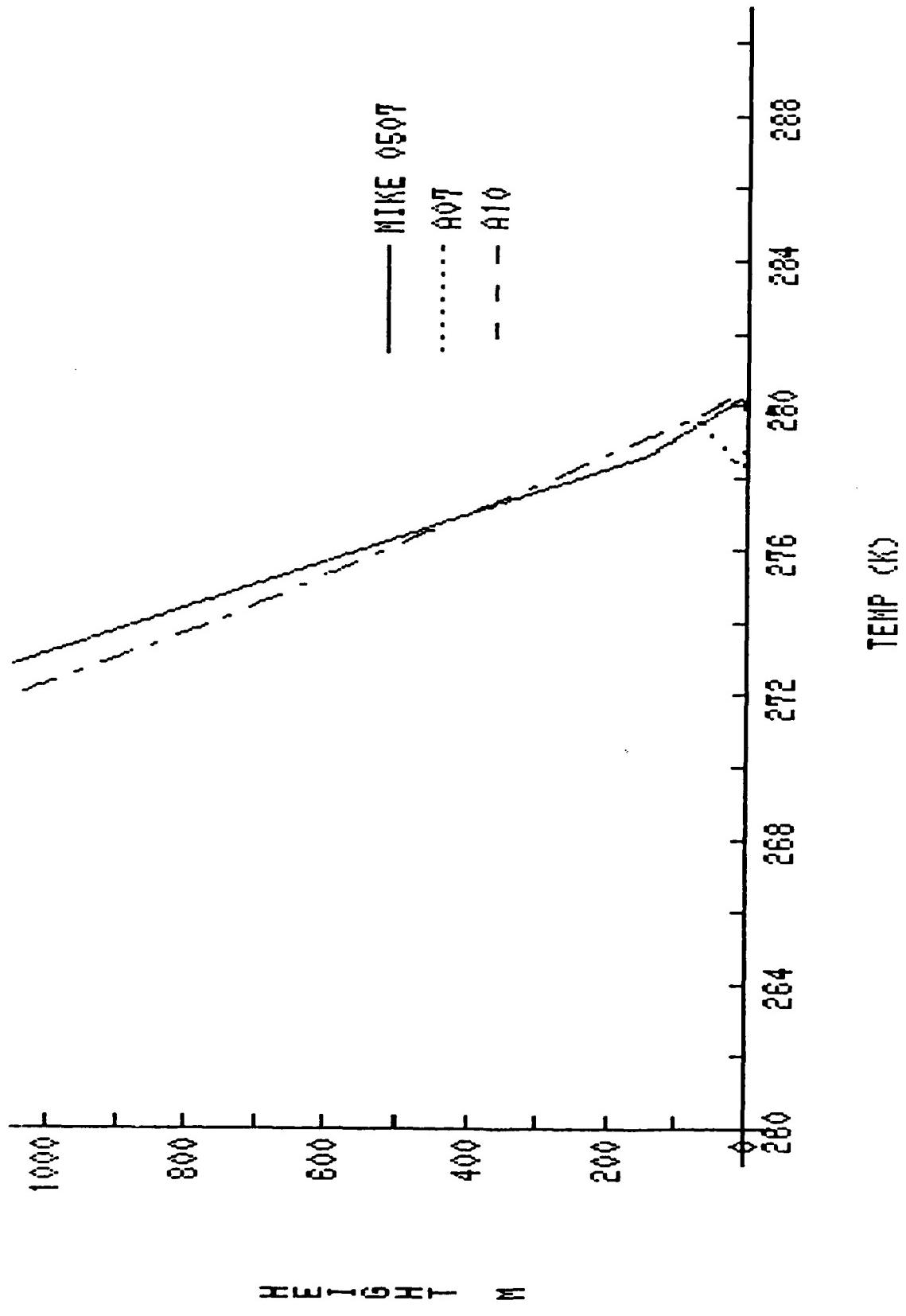
Figure 3. As in Fig. 1, for ship Mike 00Z 15 May 1986.
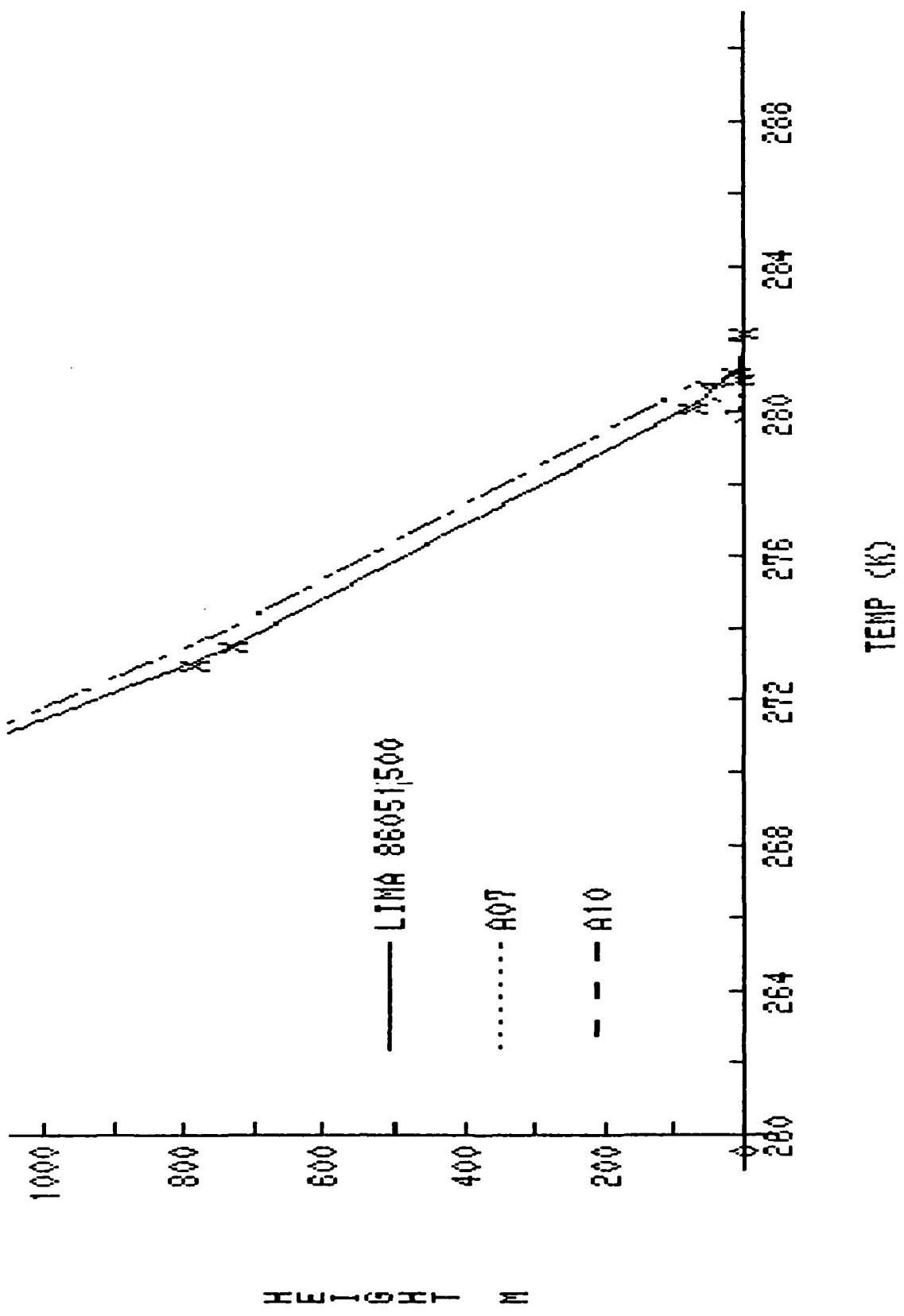
Figure 4. As in Fig. 1, for ship Lima 00Z 15 May 1986.
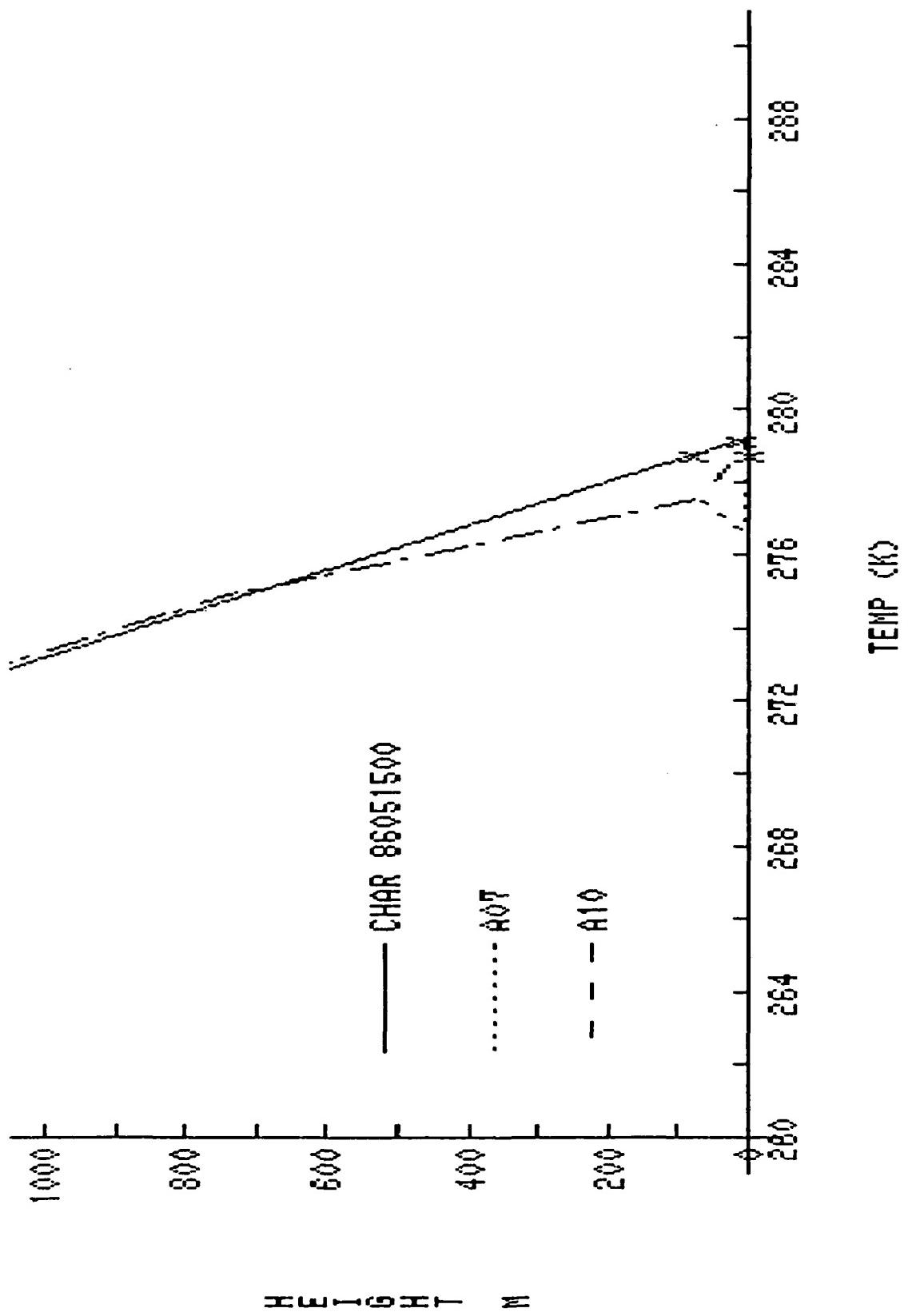
Figure 5. As in Fig. 1, for ship Charlie 00Z 15 May 1986.

TEMP (K)

HEIGHT M

MIKE 86051512

A07

A10
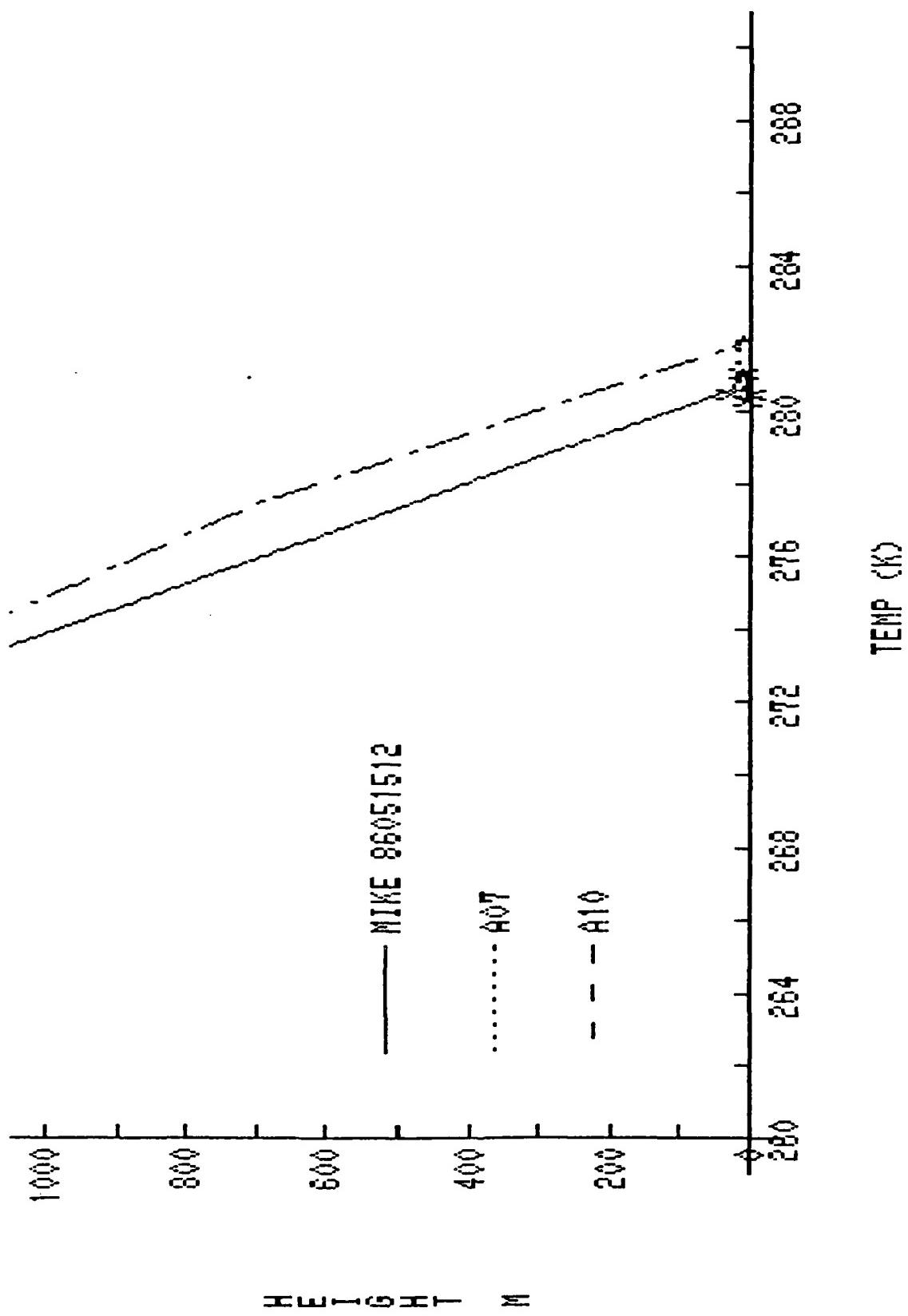
Figure 6. As in Fig. 1, for ship Mike 12Z 15 May 1986.

15
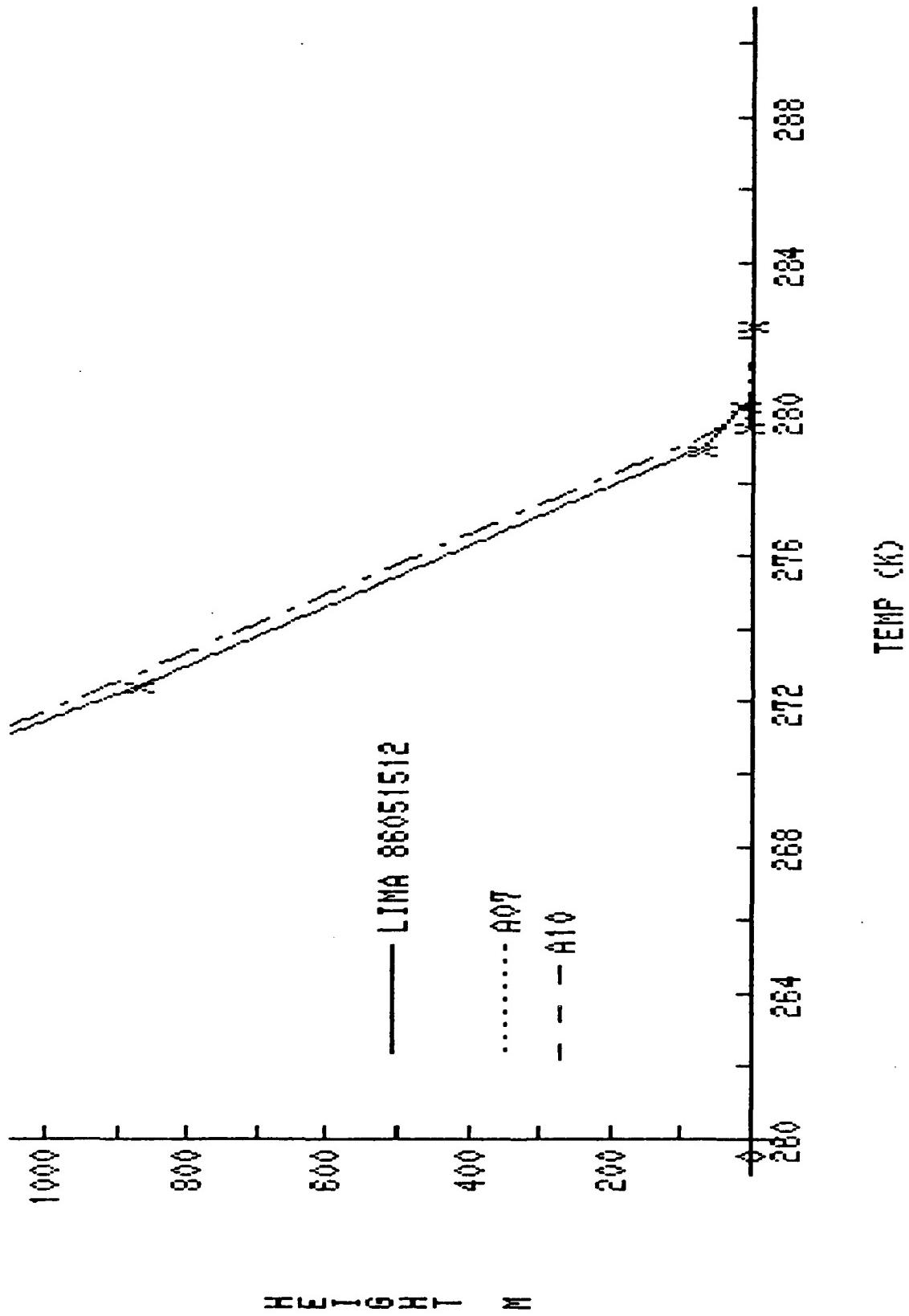
Figure 7. As in Fig. 1, for ship Lima 12⁰ 15 May 1986.
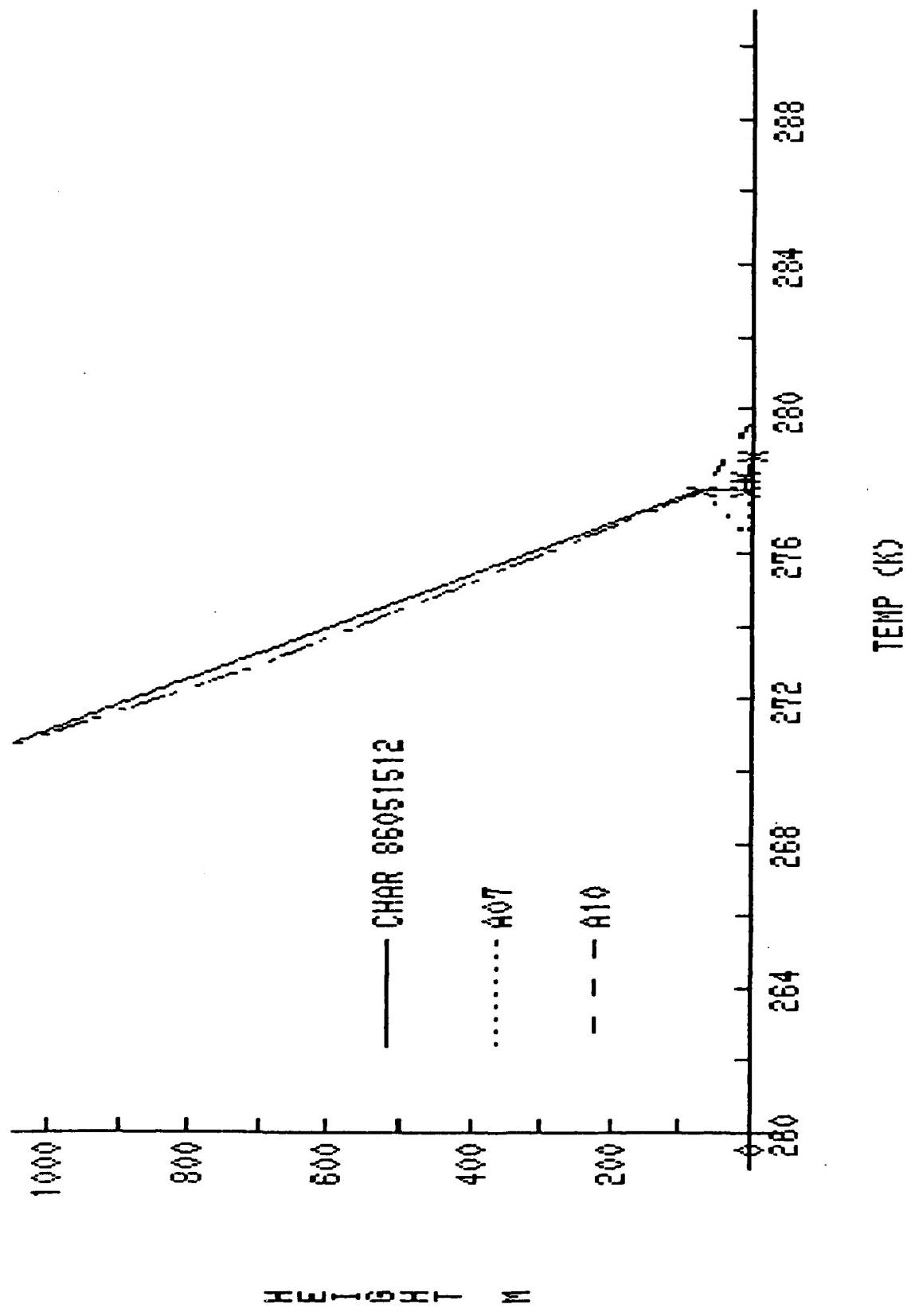
Figure 8. As in Fig. 1, for ship Charlie 12Z 15 May 1986.
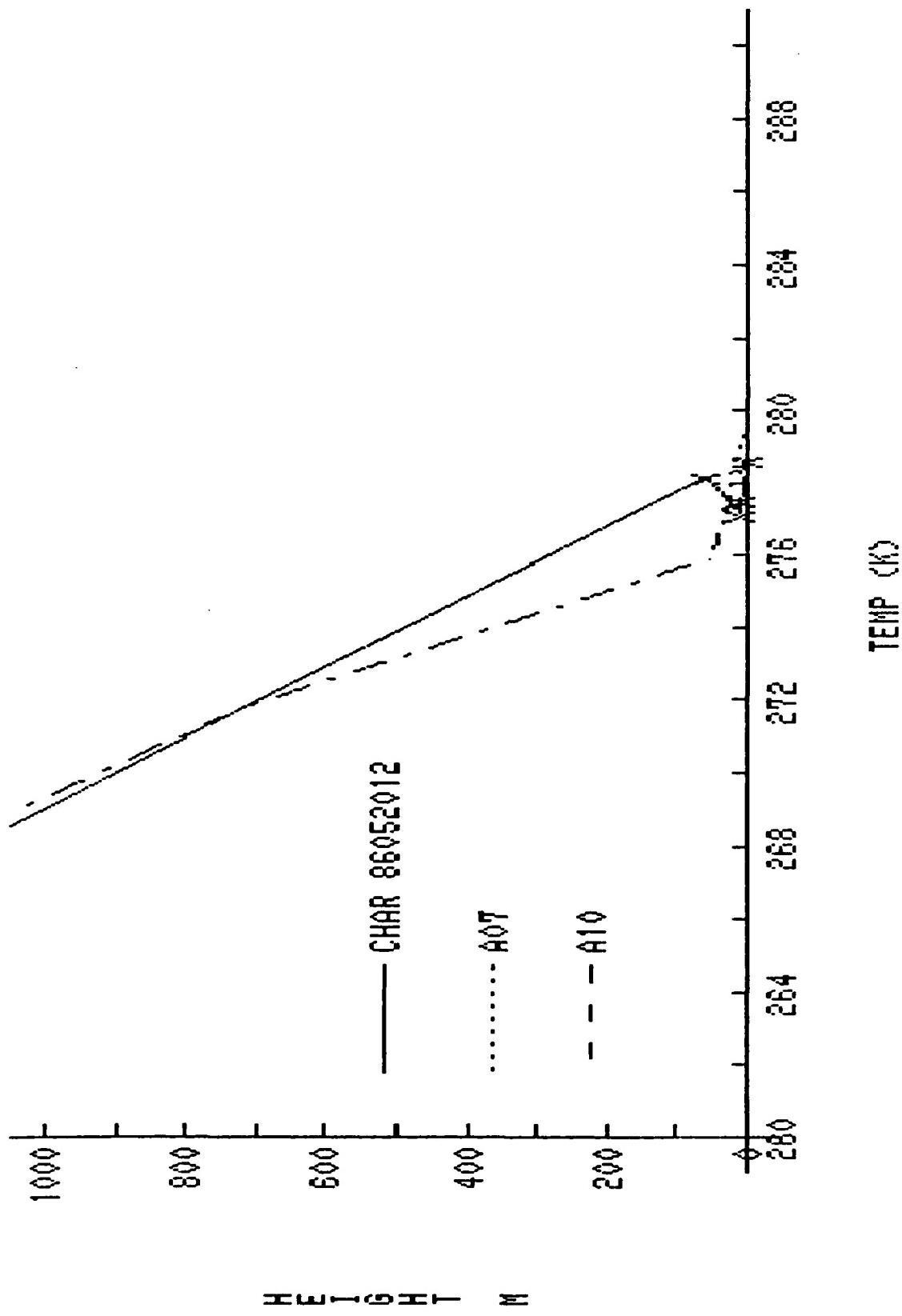
Figure 9. As in Fig. 1, for ship Charlie 12Z 20 May 1986.

CHAR 86052012
A07
A10

TEMP (K)

HEIGHT M
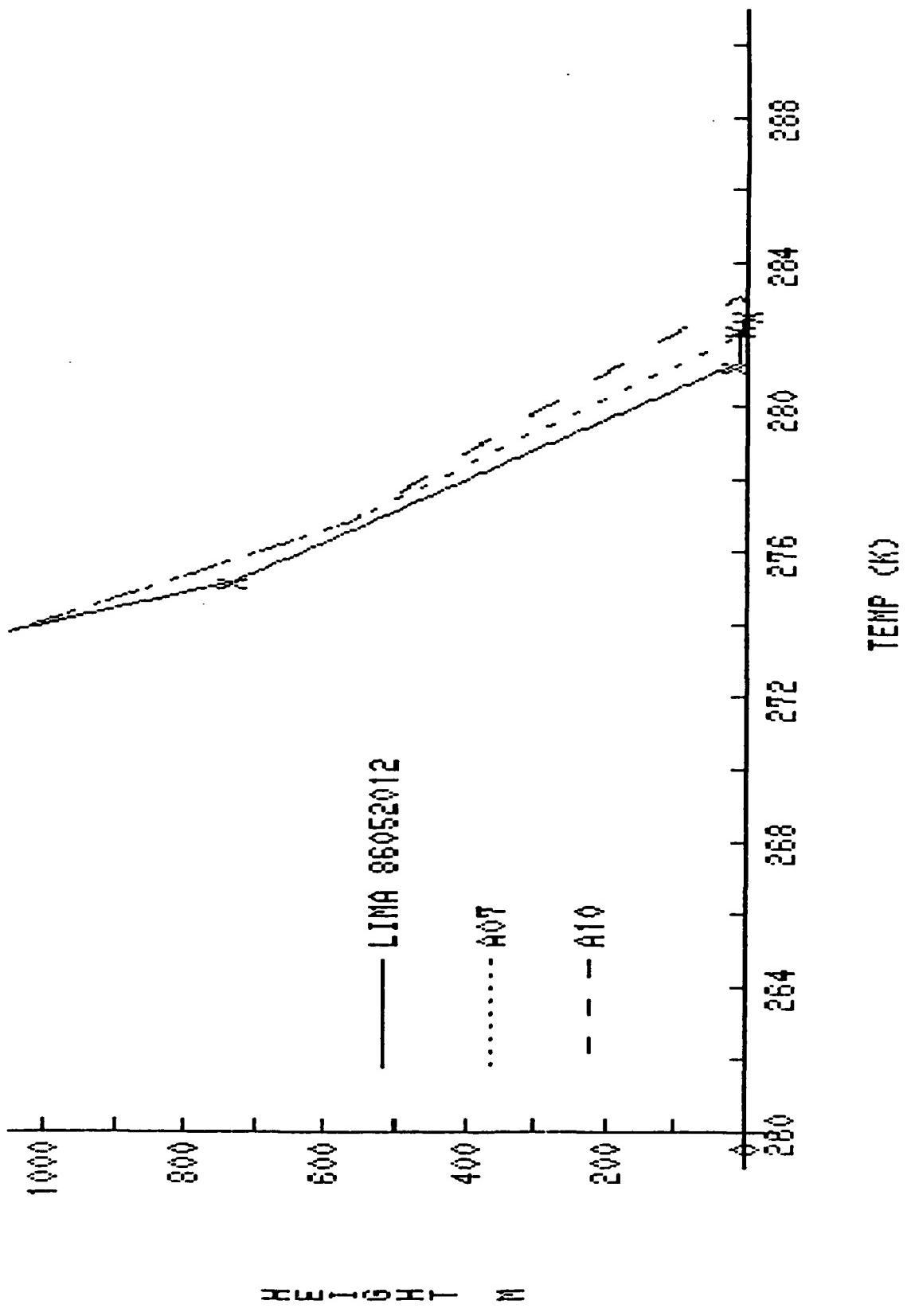
Figure 10. As in Fig. 1, for ship Lima 12Z 20 May 1986.

19
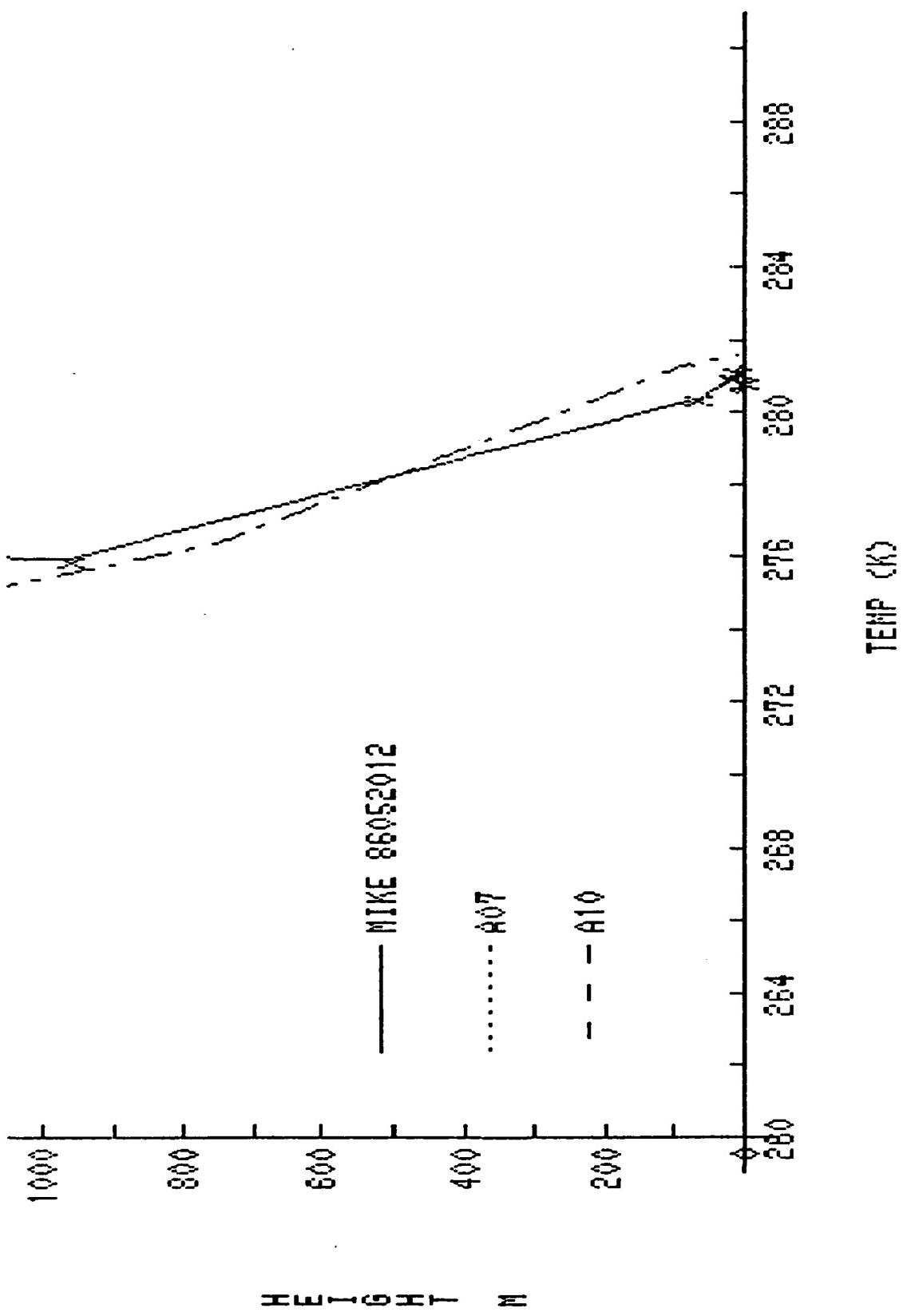
Figure 11. As in Fig. 1, for ship Mike 12Z 20 May 1986.

20
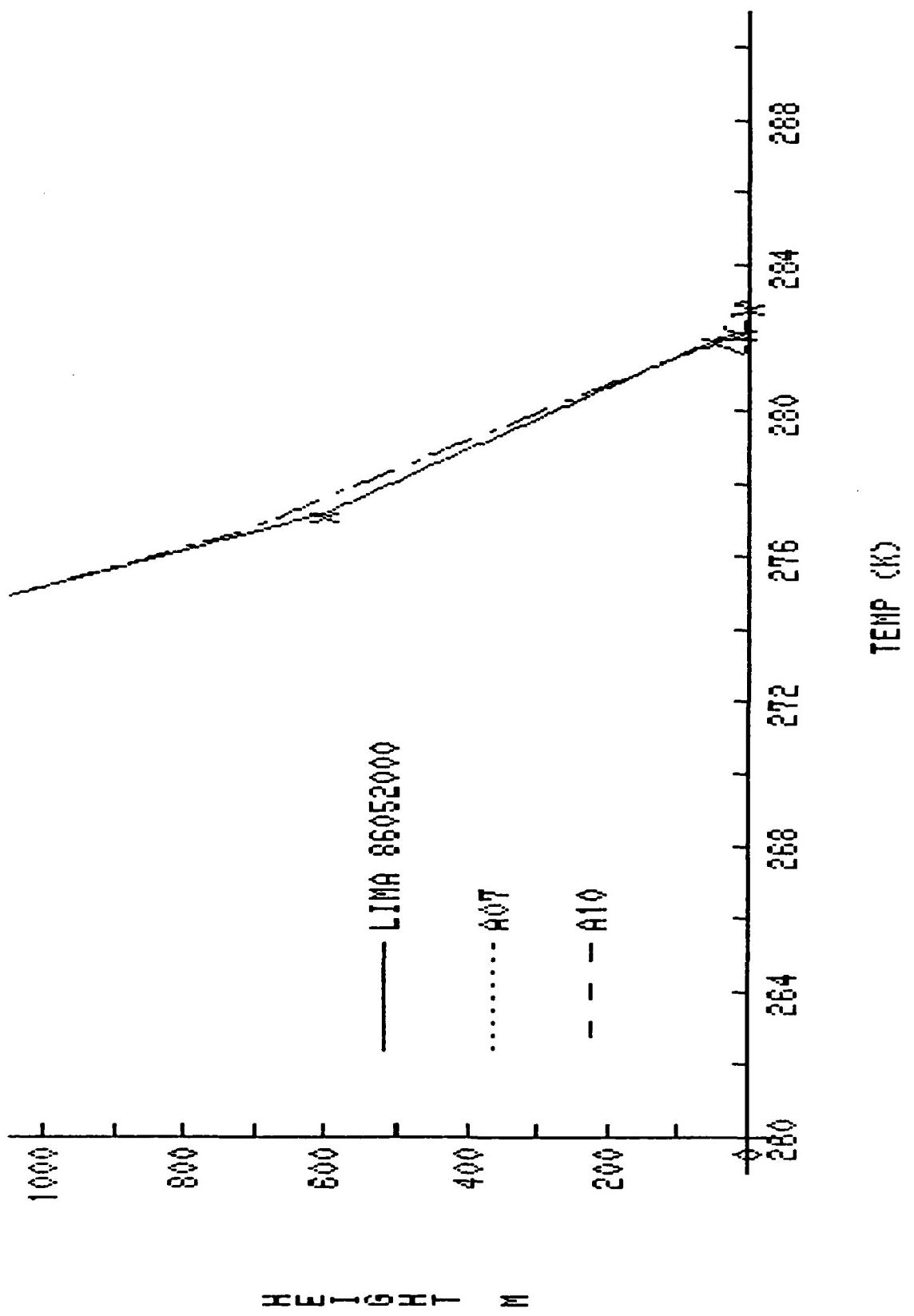
Figure 12. As in Fig. 1, for ship Lima 00Z 20 May 1986.

TEMP (K)

HEIGHT M

LIMA 86052000
A07
A10
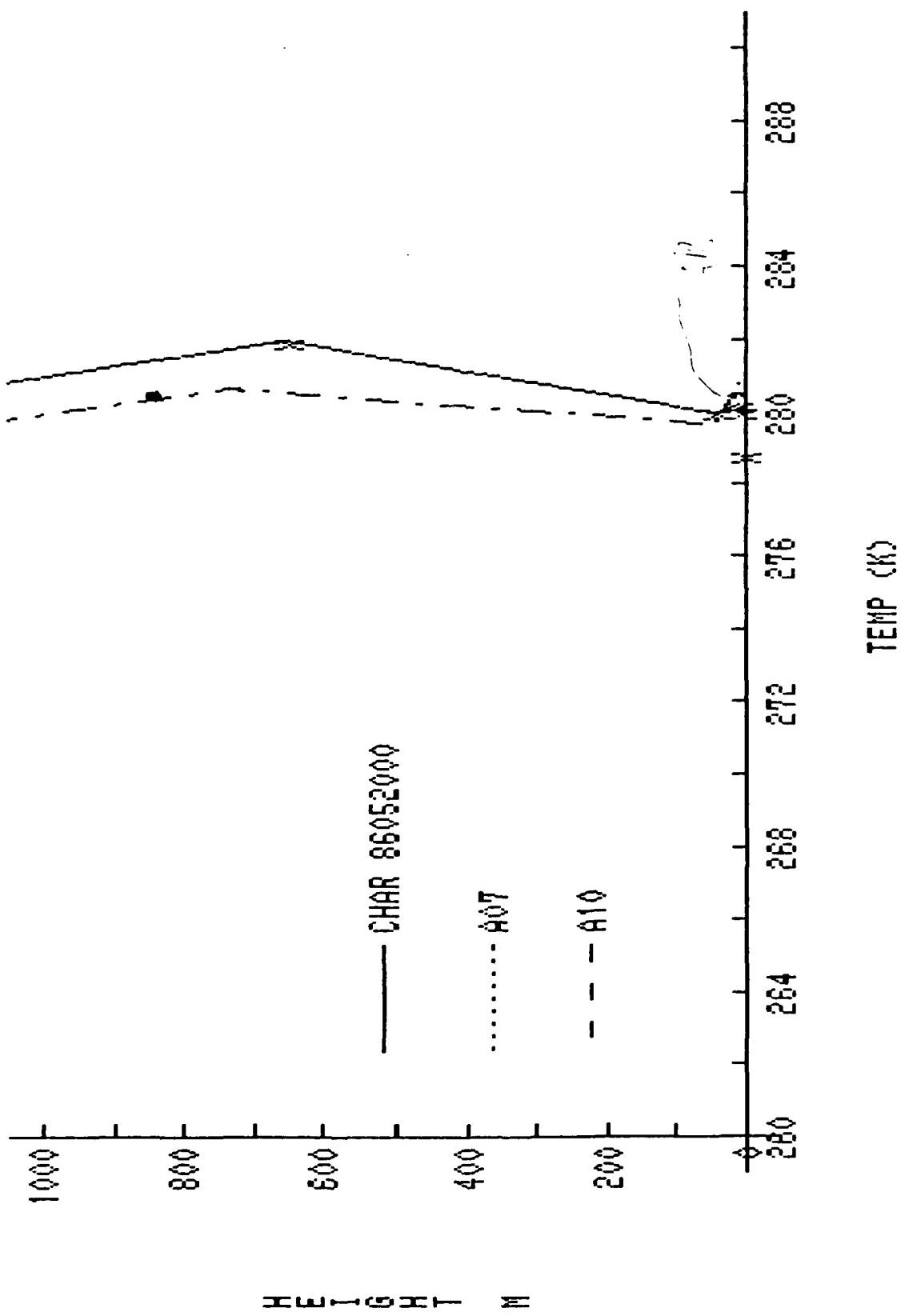
Figure 13. As in Fig. 1, for ship Charlie 00Z 20 May 1986.
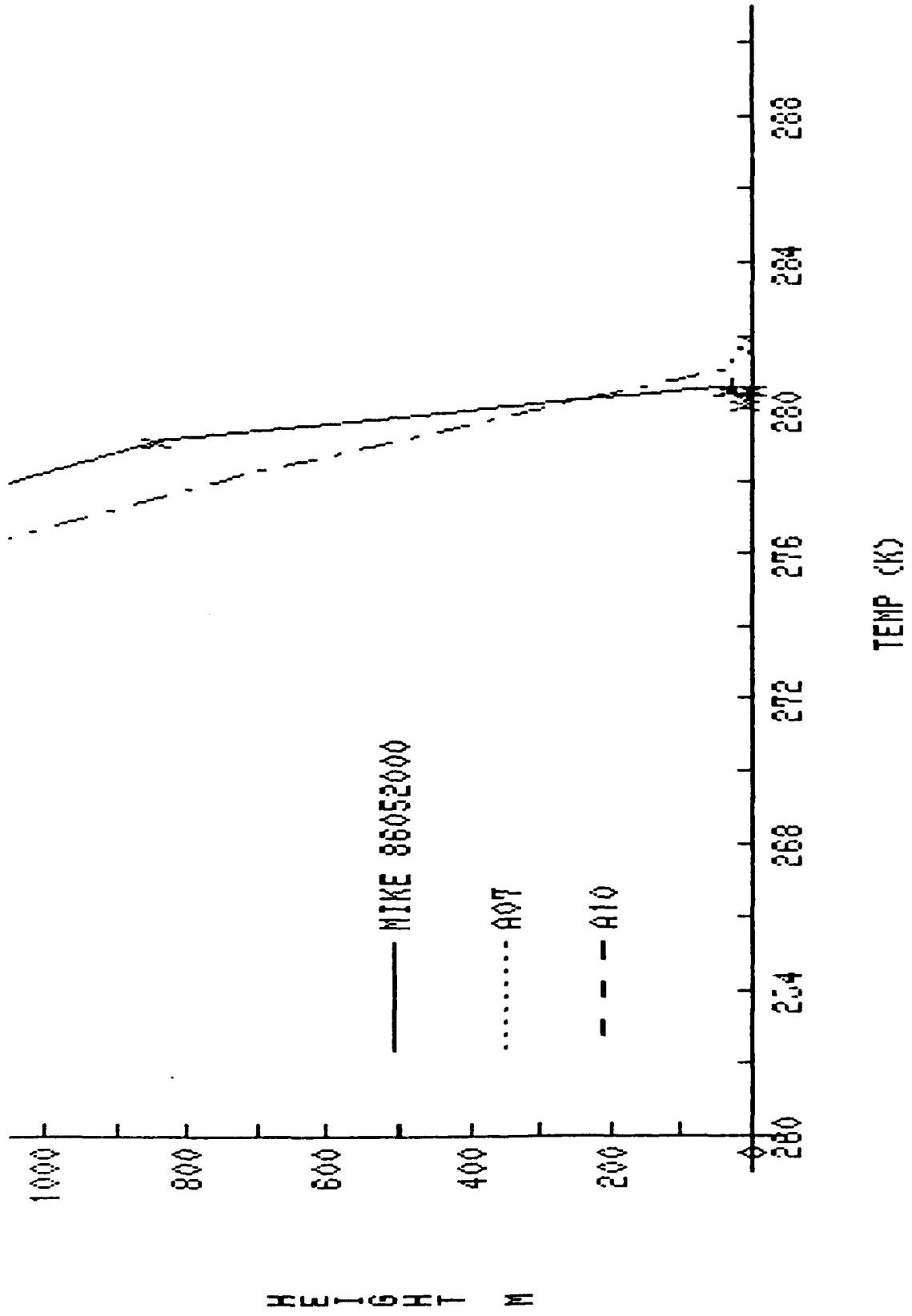
Figure 14.   As in Fig. 1, for ship Mike 00Z 20 May 1986.
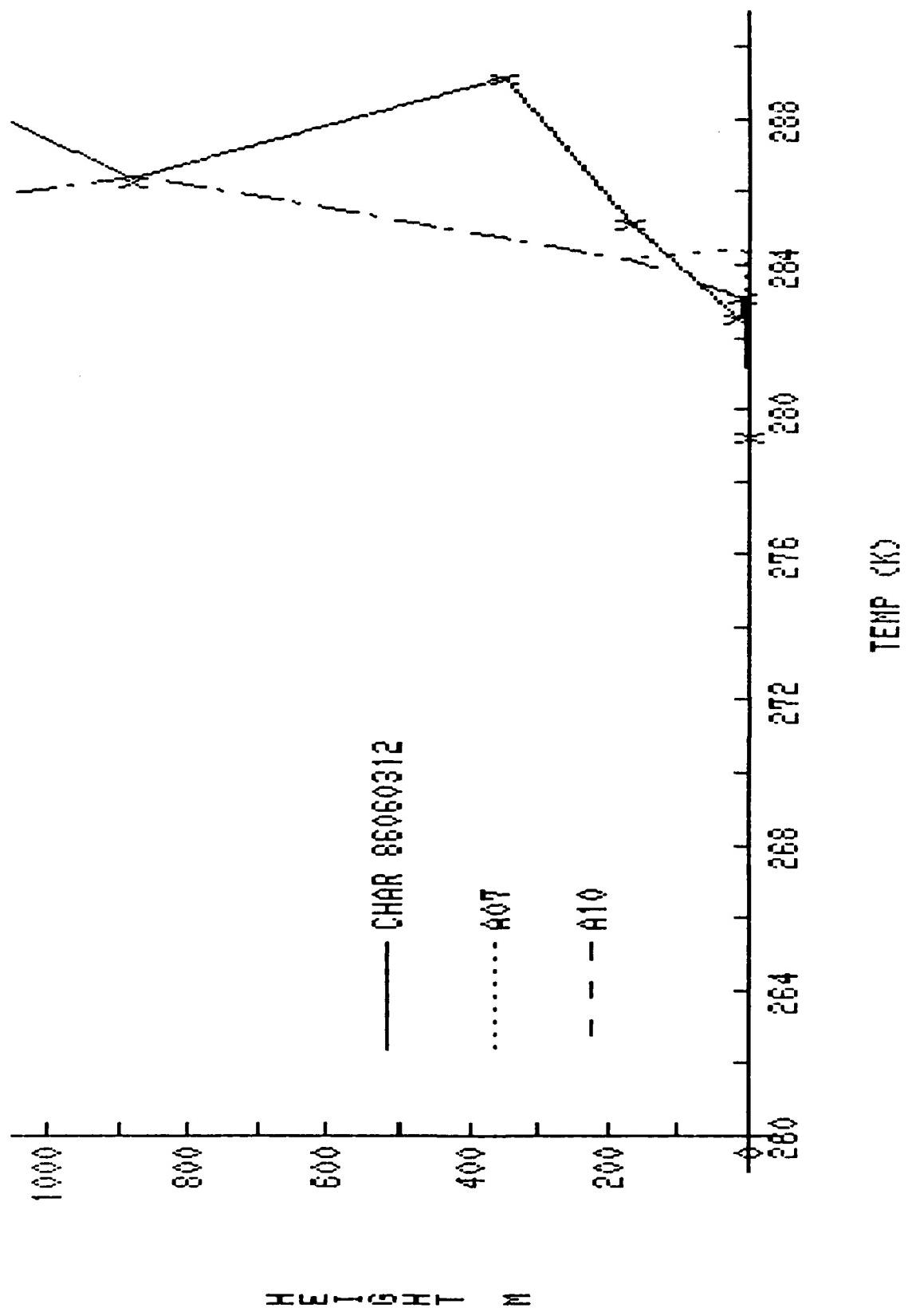
Figure 15. As in Fig. 1, for ship Charlie 12Z 3 June 1986.

24
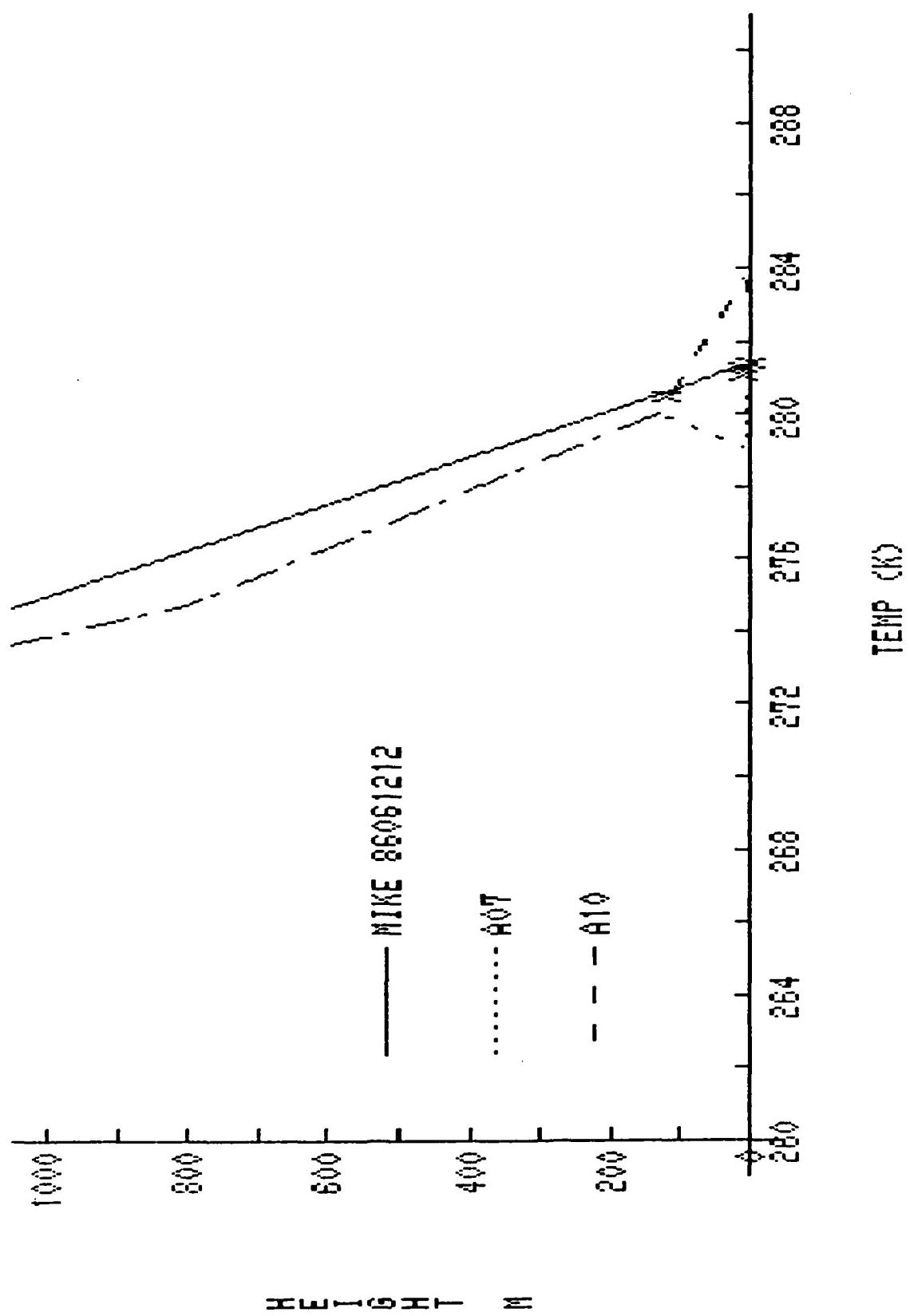
Figure 16. As in Fig. 1, for ship Mike 12Z 12 June 1986.
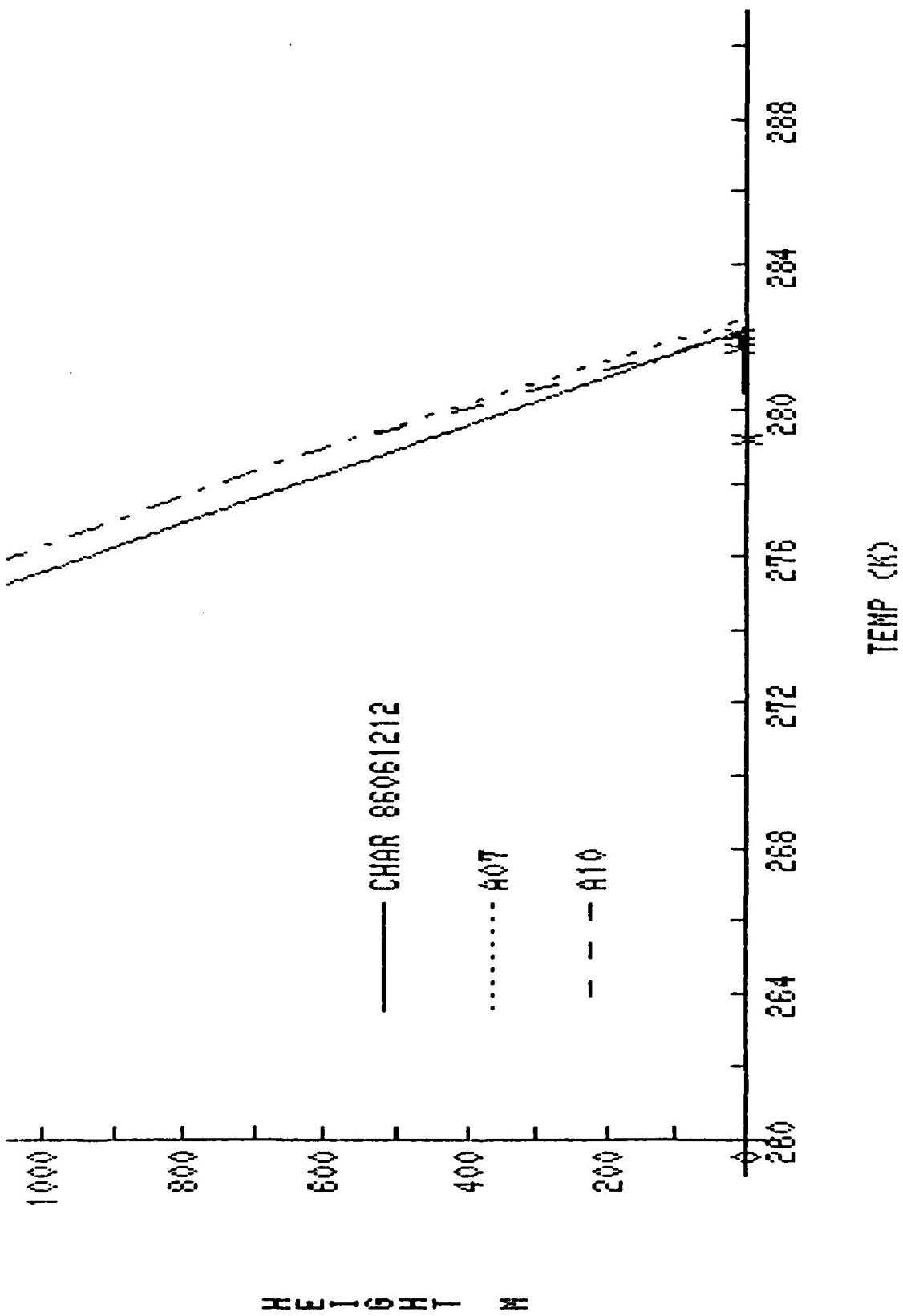
Figure 17. As in Fig. 1, for ship Charlie 12Z 12 June 1986.
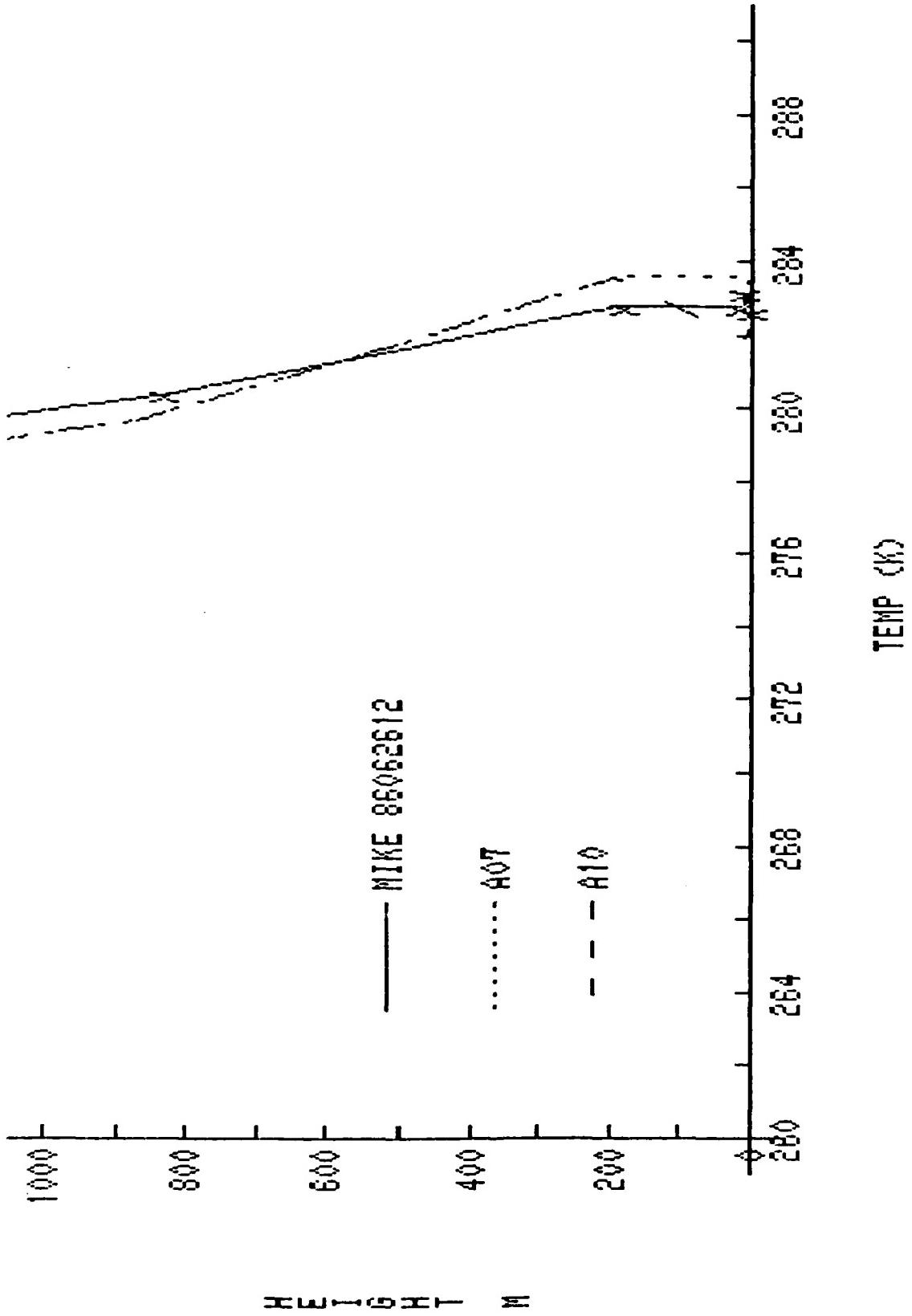
Figure 18. As in Fig. 1, for ship Mike 12Z 26 June 1986.

27
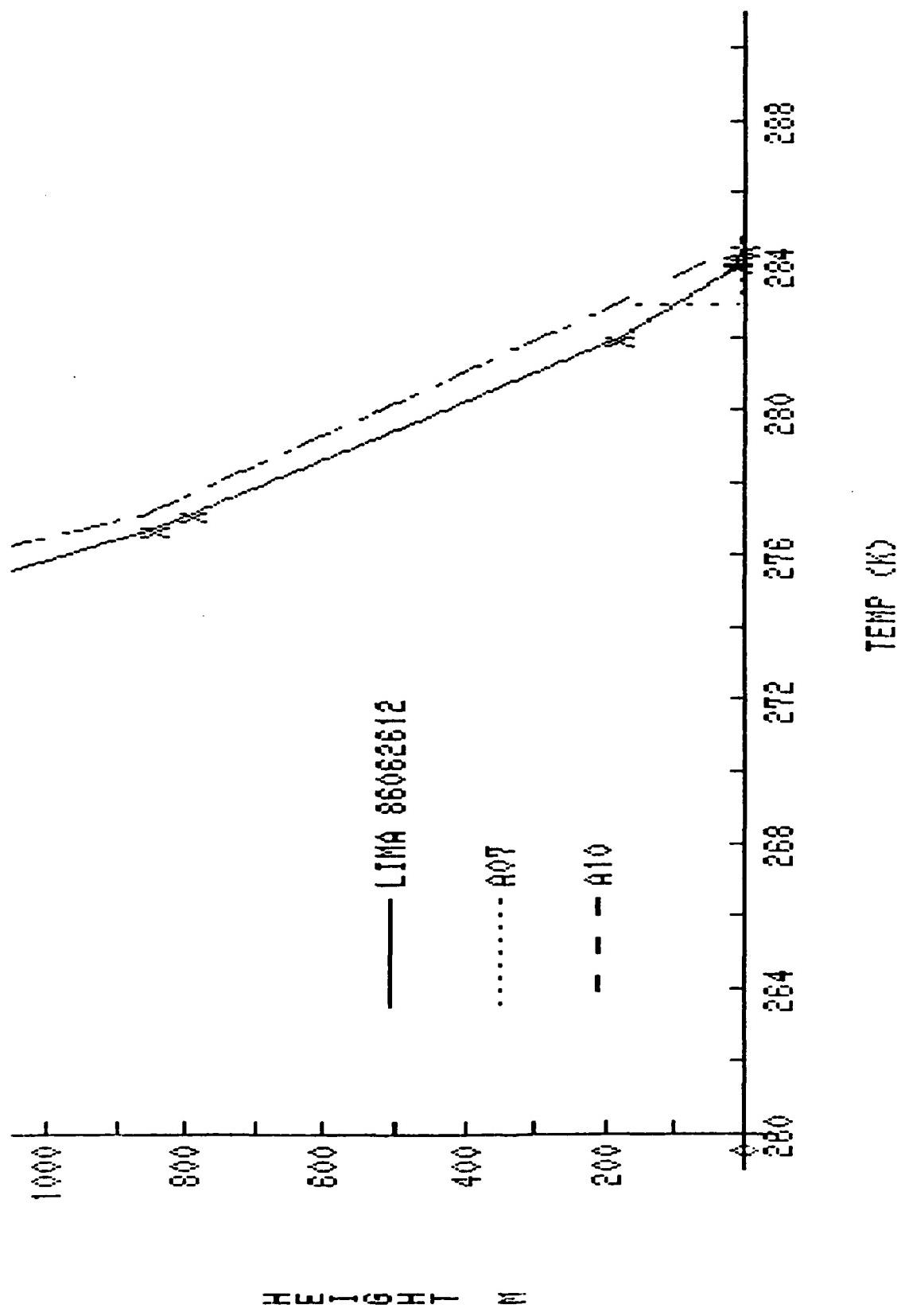
Figure 19. As in Fig. 1, for ship Lima 12Z 26 June 1986.
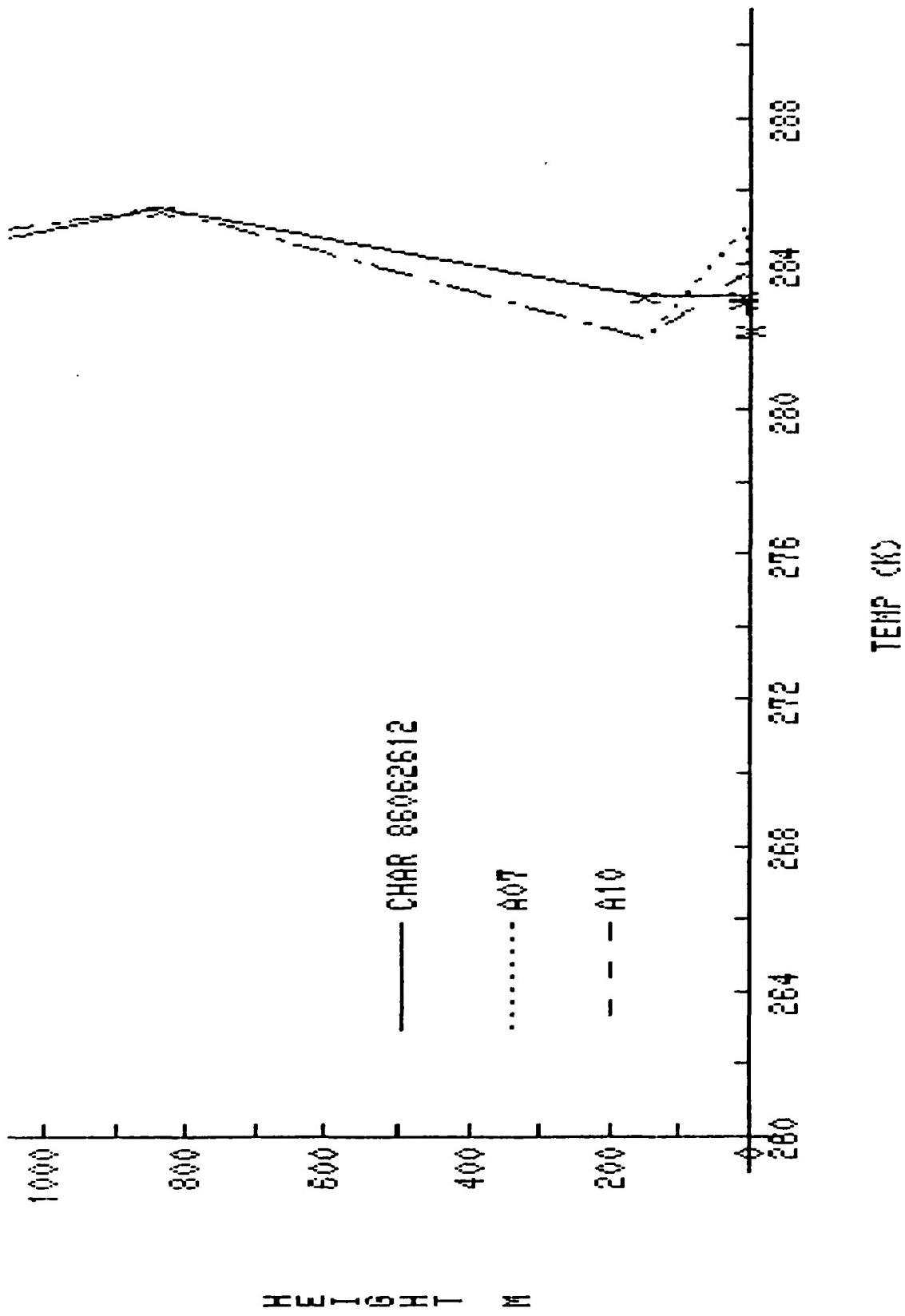
Figure 20. As in Fig. 1, for ship Charlie 12Z 26 June 1986.
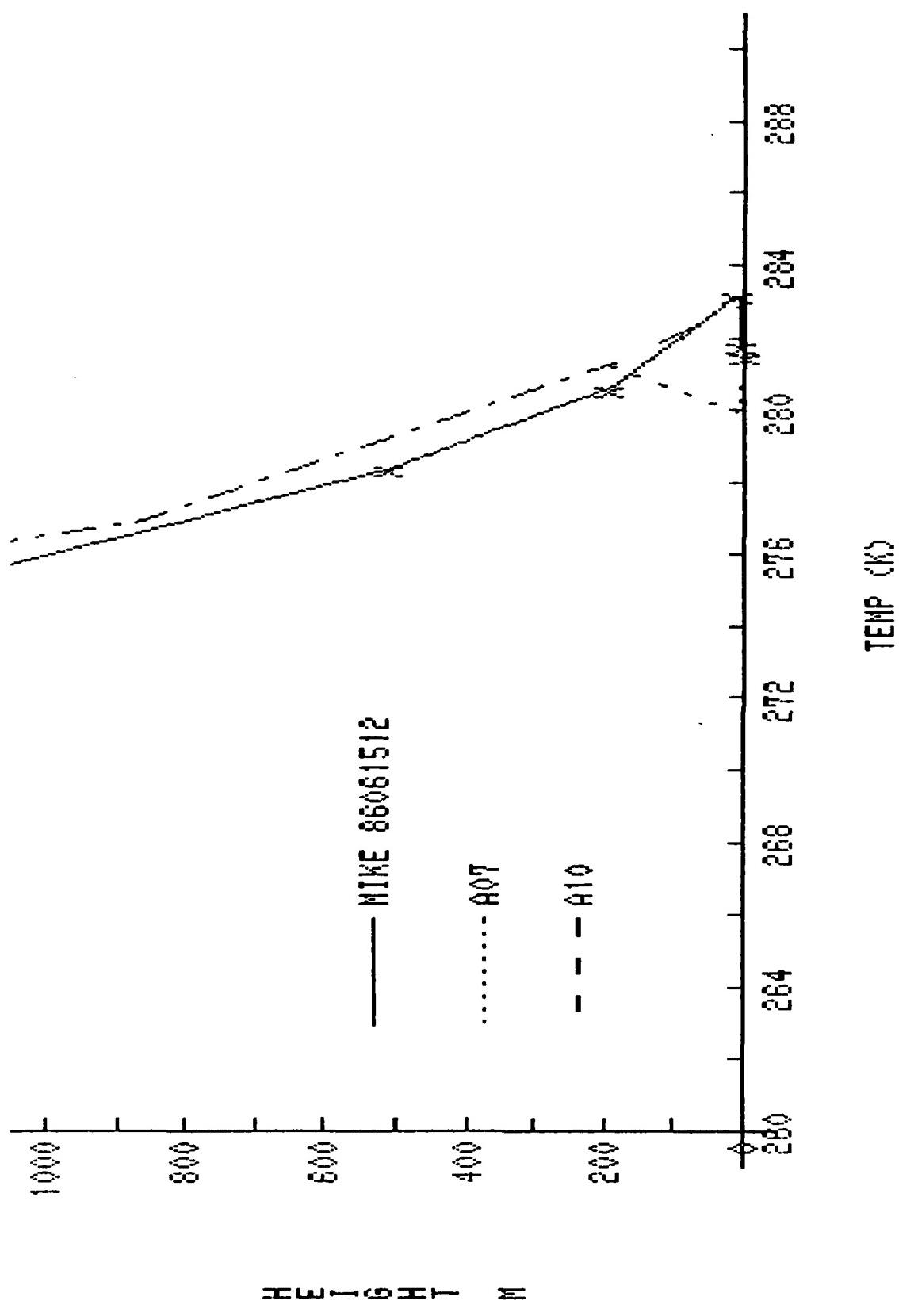
Figure 21. As in Fig. 1, for ship Mike 12Z 15 June 1986.

TEMP (K)

HEIGHT M

MIKE 86061512
A07
A10
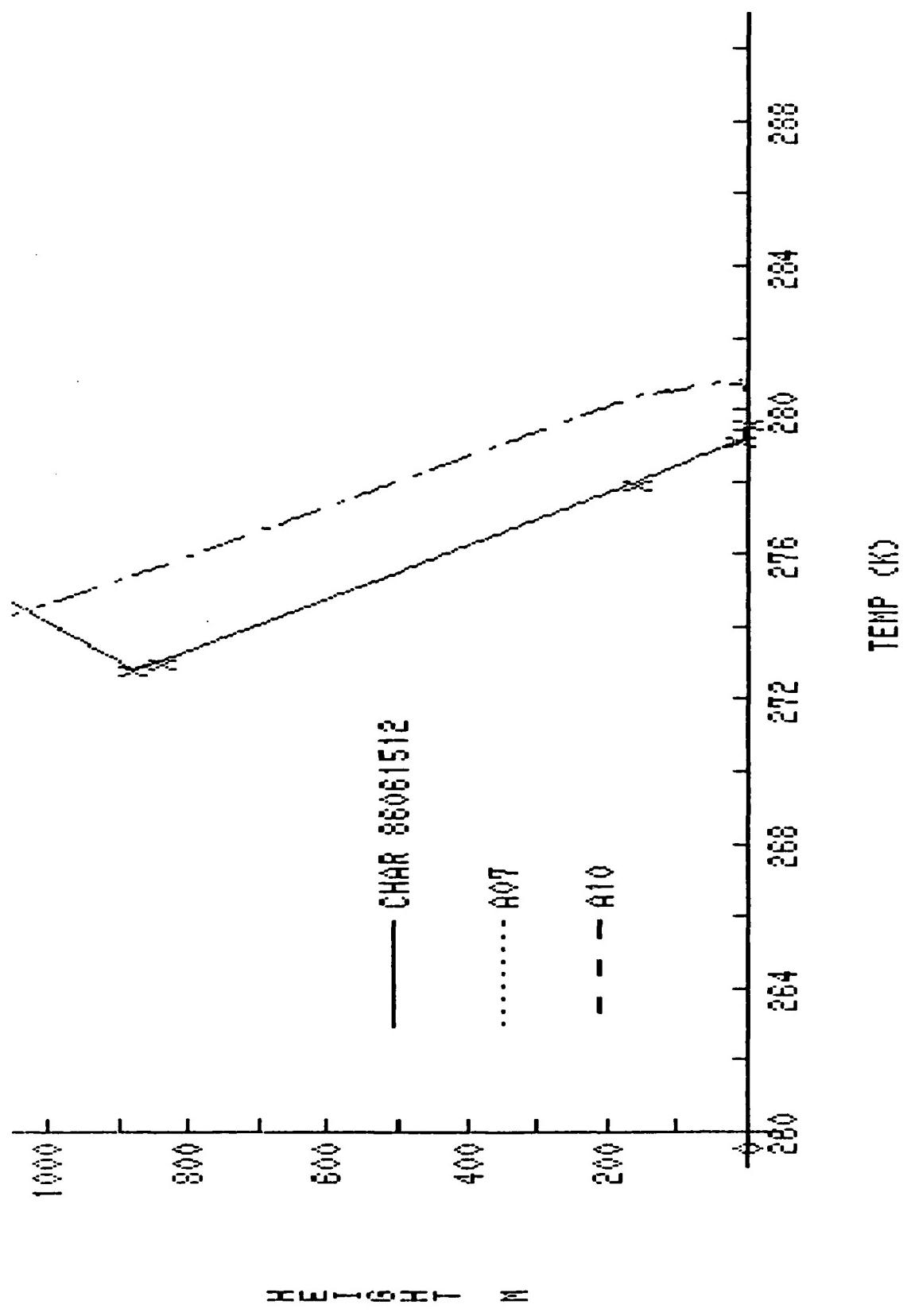
Figure 22. As in Fig. 1, for ship Charlie 12Z 15 June 1986.

31

HEIGHT M

1000

800

600

400

200

0

280 284 288 272 276 280 284 288

TEMP (K)

——— LIMA 86061512

·········· A07

— — A10
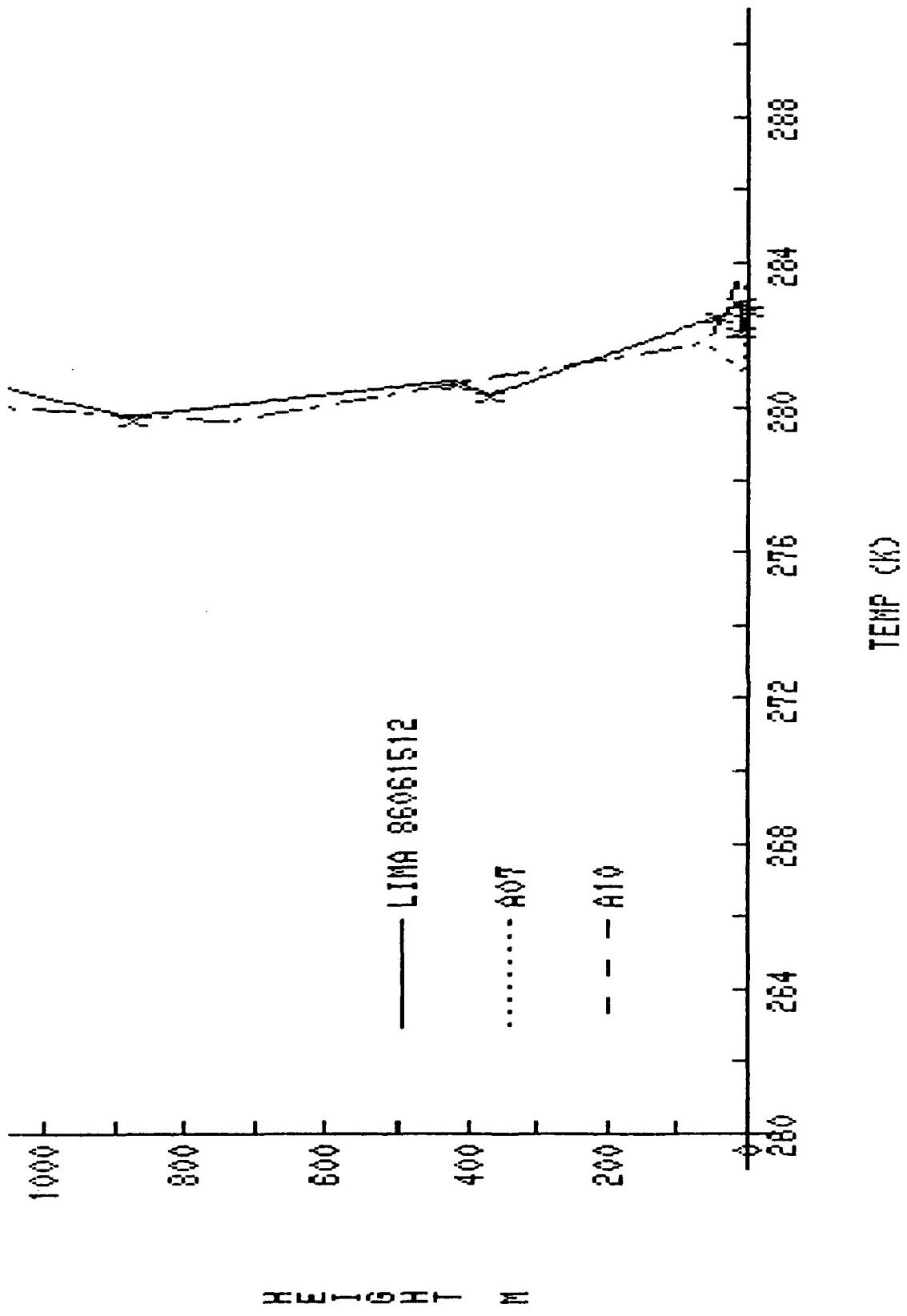
Figure 23. As in Fig. 1, for ship Lima 12Z 15 June 1986.

32
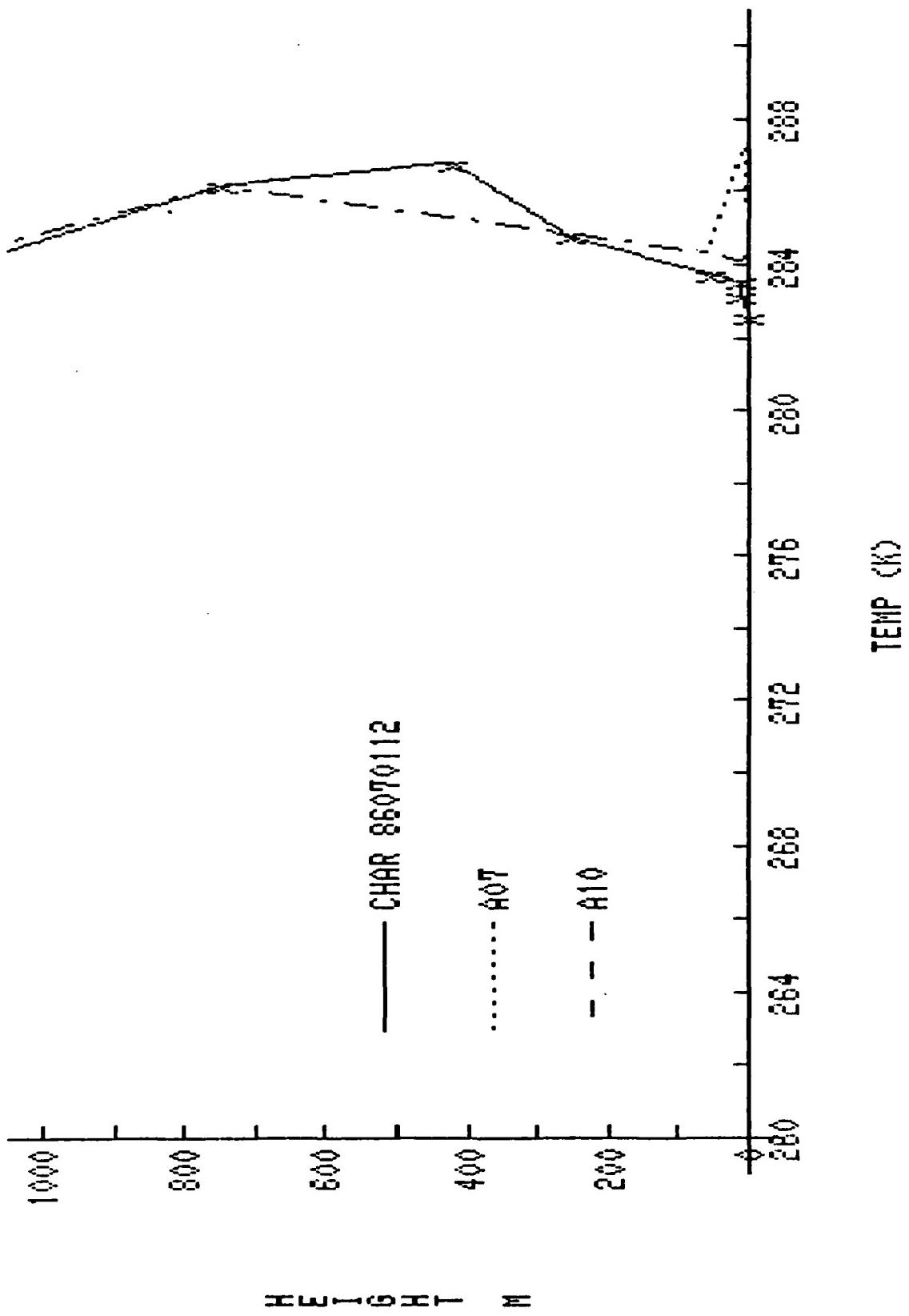
Figure 24. As in Fig. 1, for ship Charlie 12Z 1 July 1986.
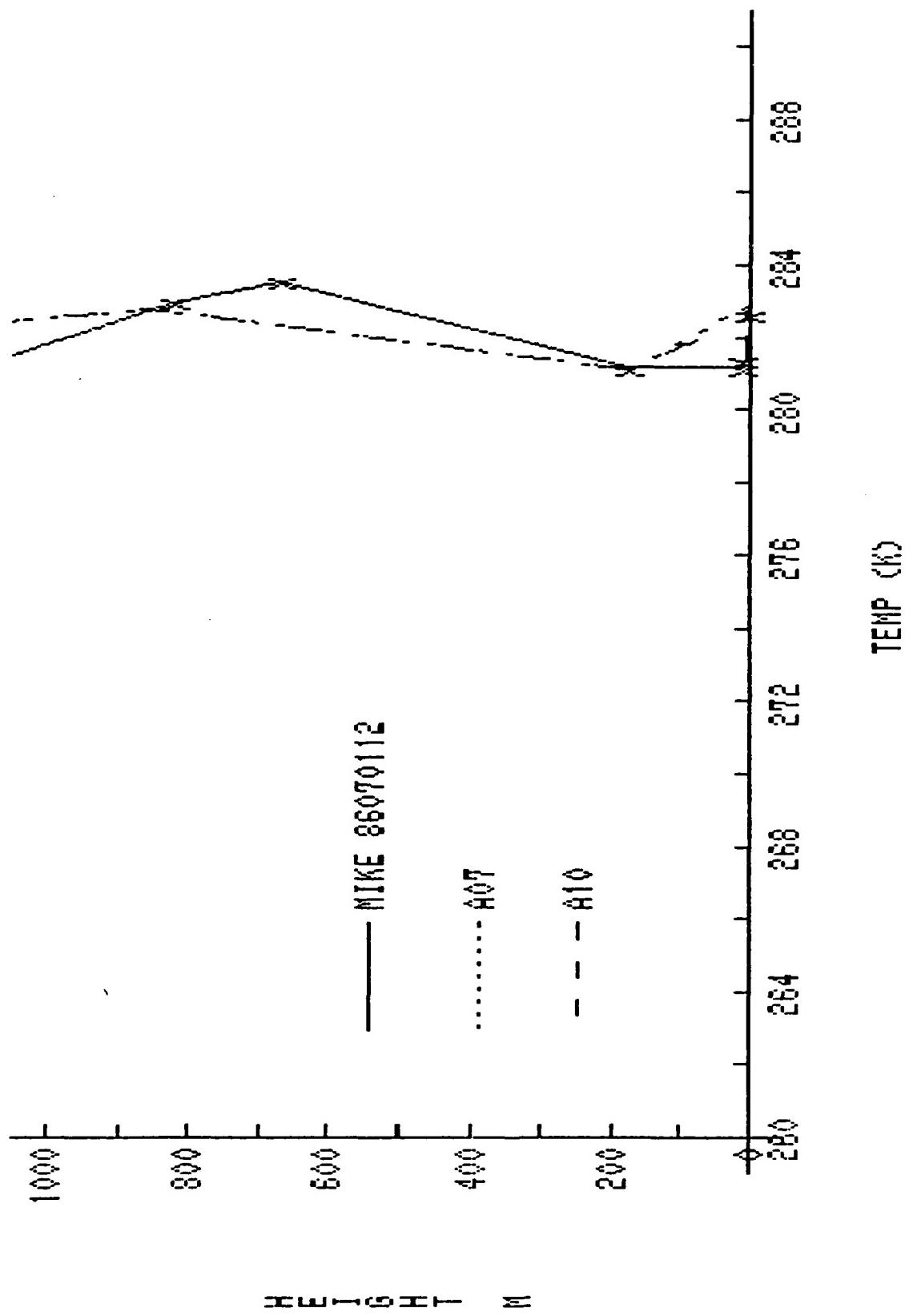
Figure 25. As in Fig. 1, for ship Mike 12Z 1 July 1986.

TEMP (K)

HEIGHT M

MIKE 86070112
.... A07
— — A10
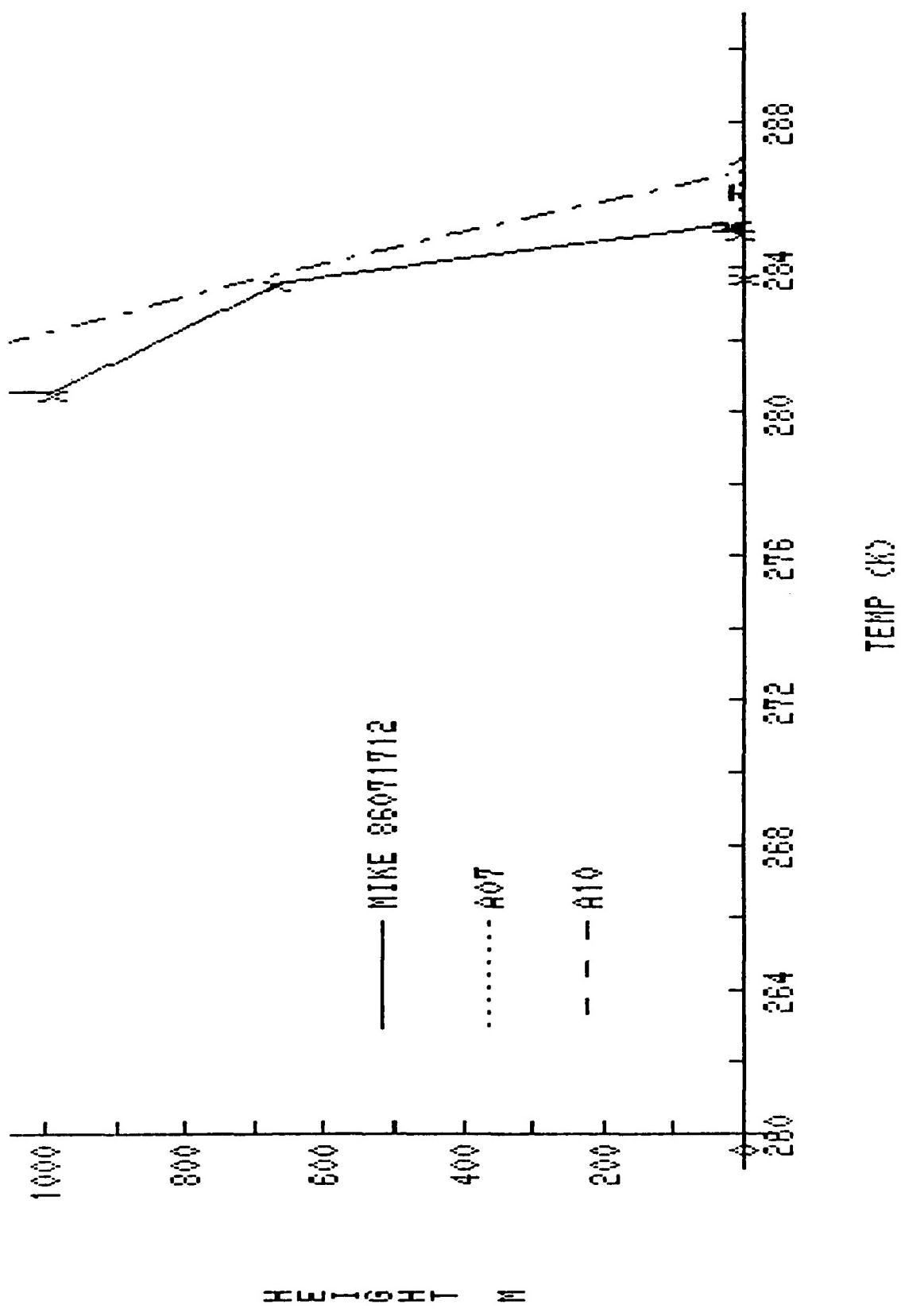
Figure 26. As in Fig. 1, for ship Mike 12Z 17 July 1986.
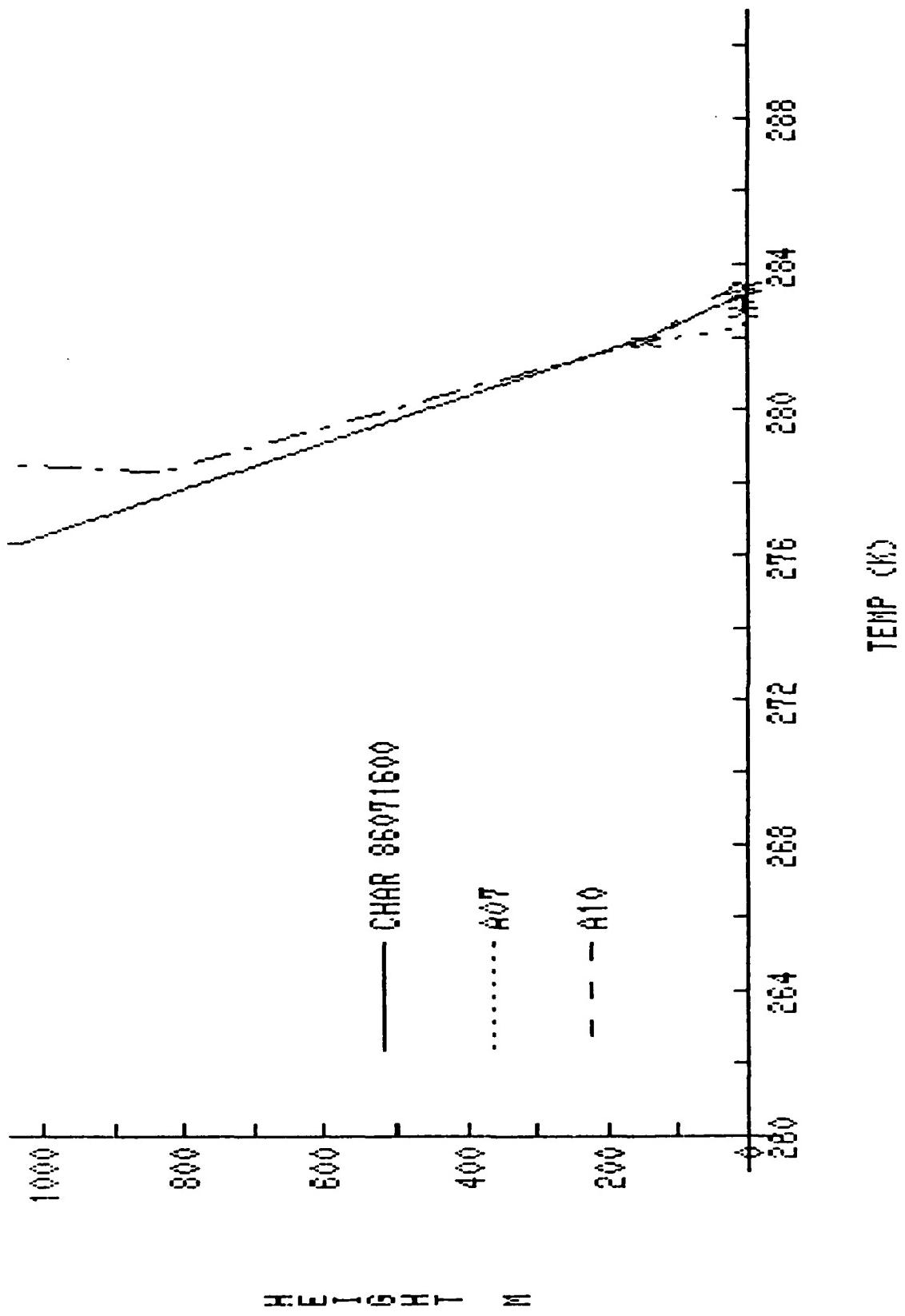
Figure 27. As in Fig. 1, for ship Charlie 00Z 16 July 1986.

TEMP (K)

HEIGHT M

CHAR 86071600
AOT
A10
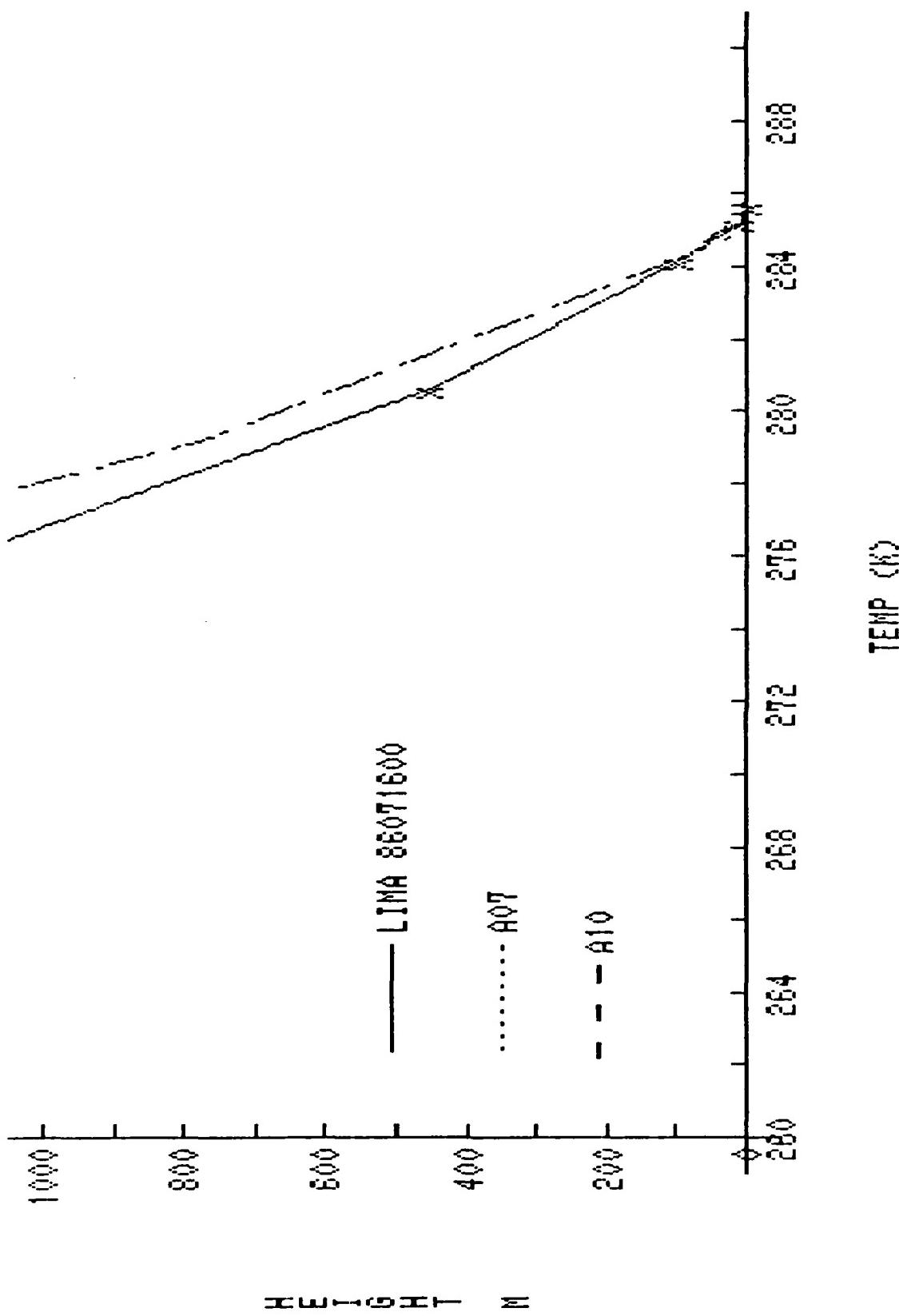
Figure 28. As in Fig. 1, for ship Lima 00Z 16 July 1986.
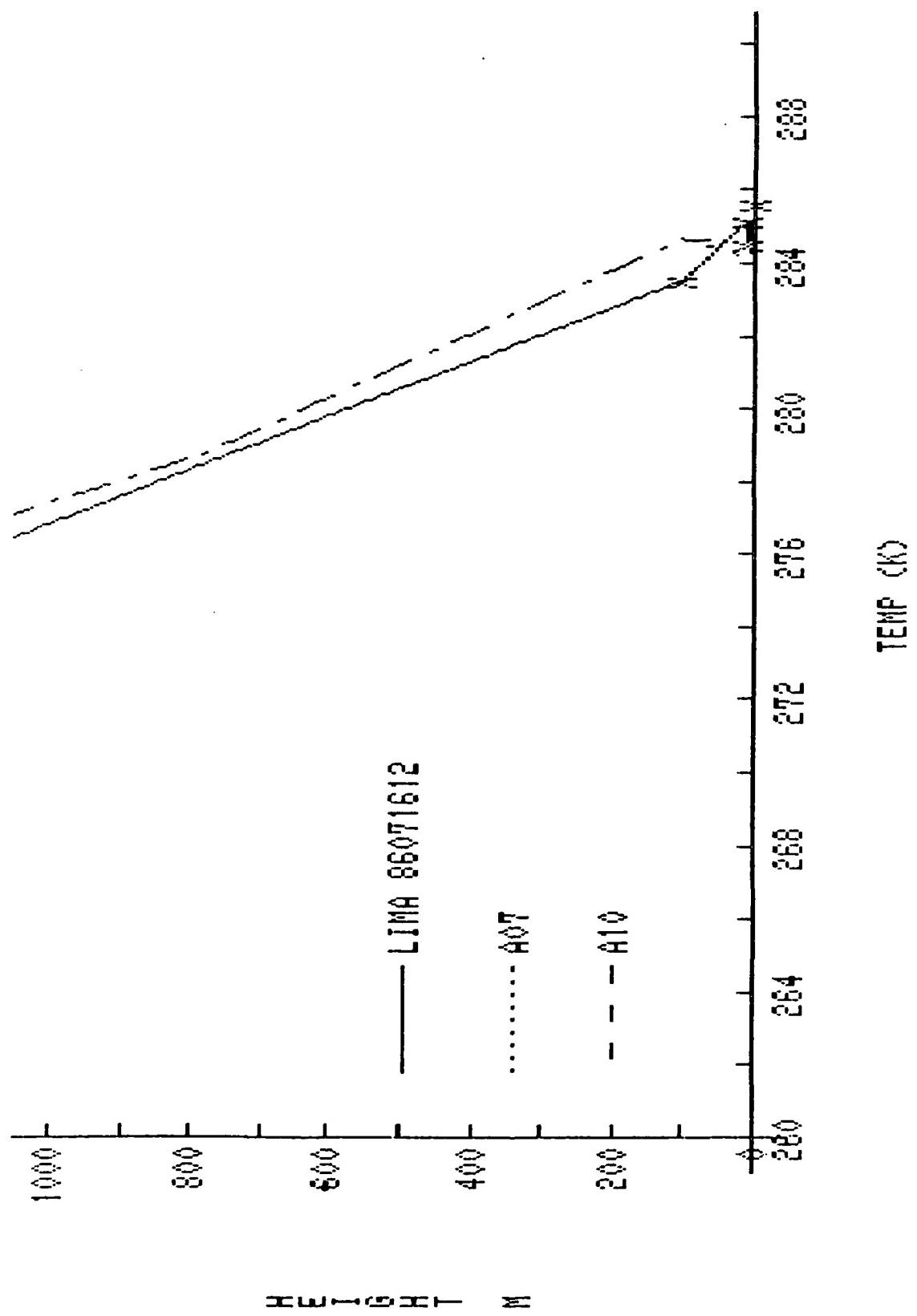
Figure 29. As in Fig. 1, for ship Lima 12Z 16 July 1986.

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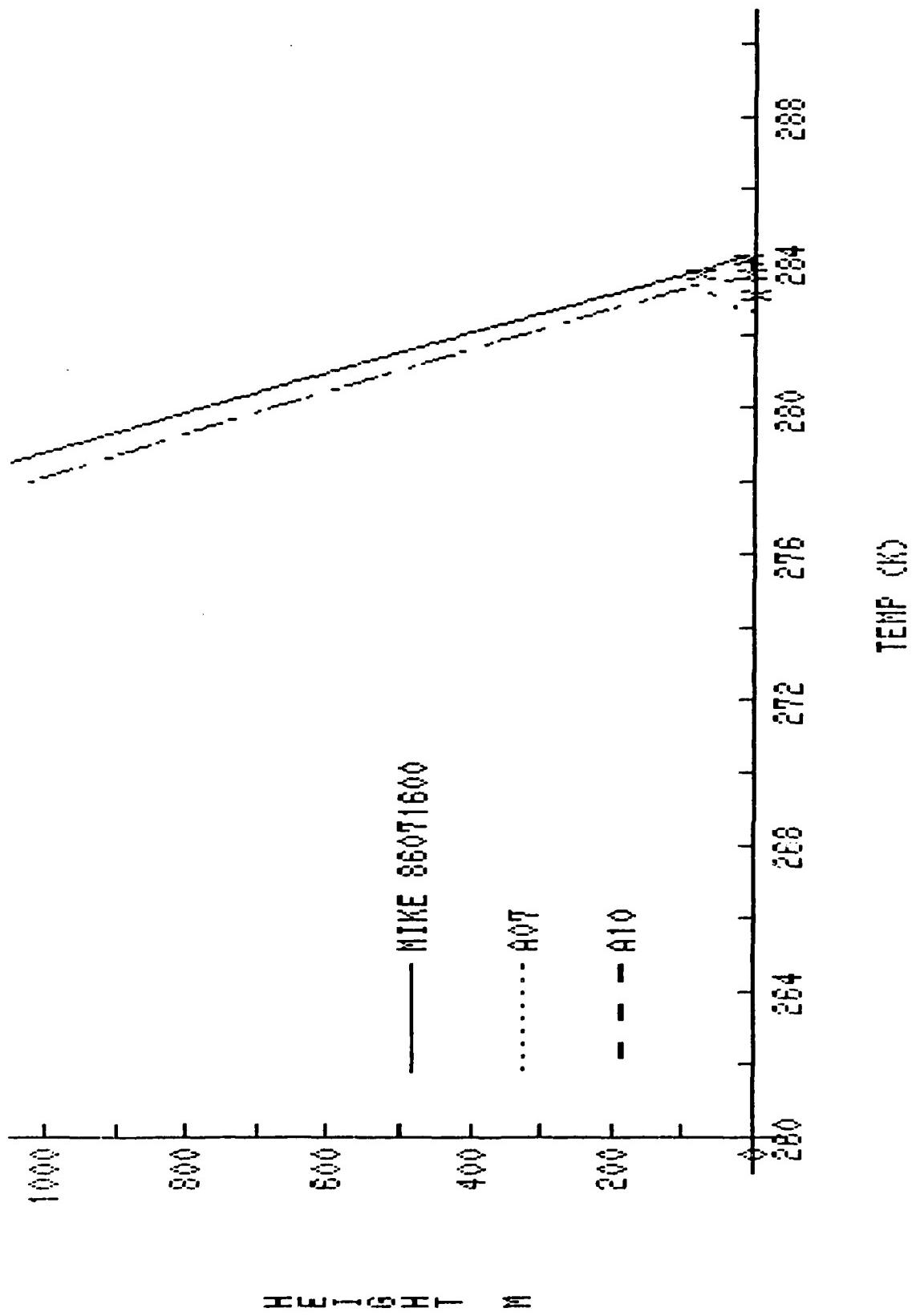
Figure 30. As in Fig. 1, for ship Mike 00Z 16 July 1986.
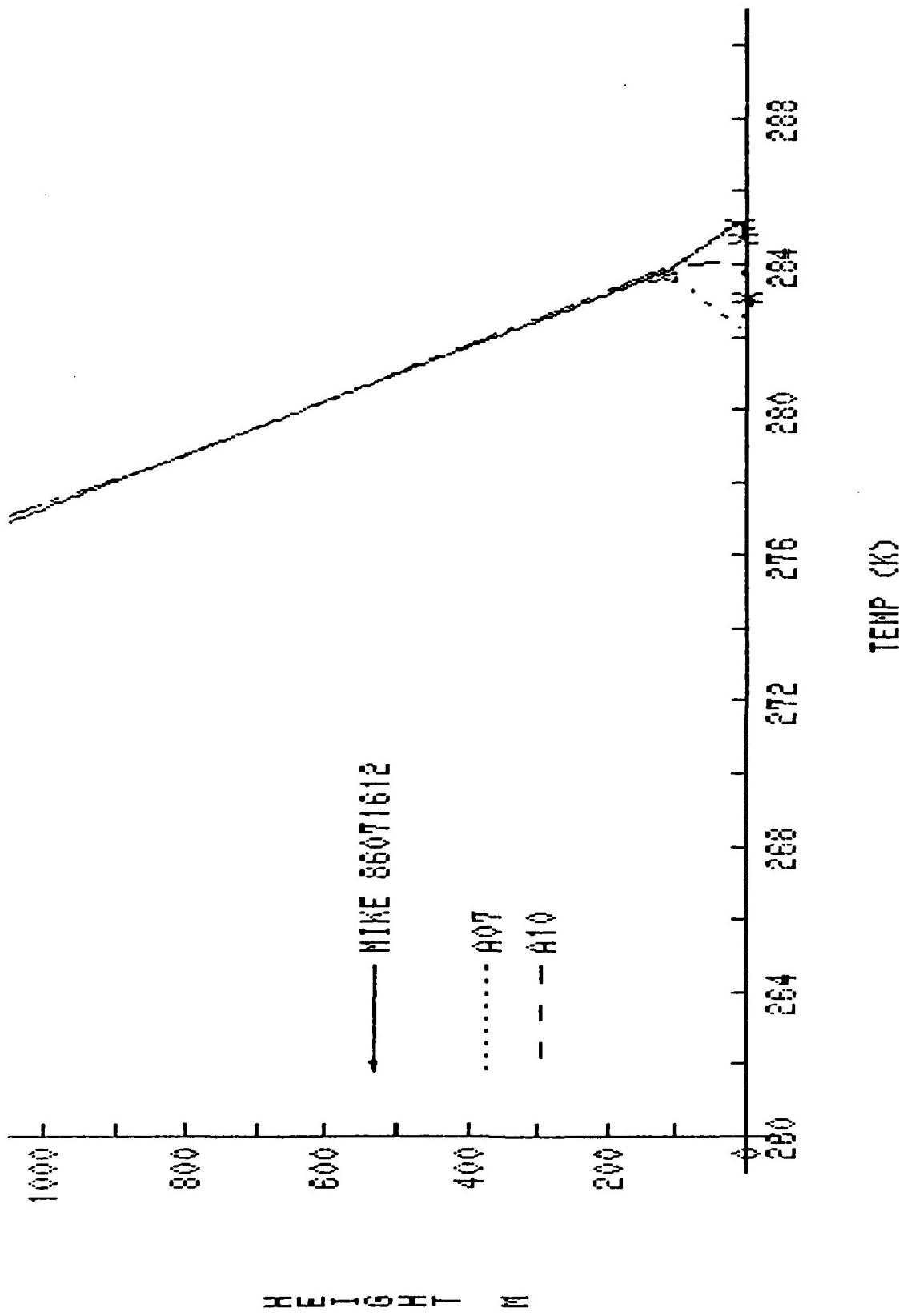
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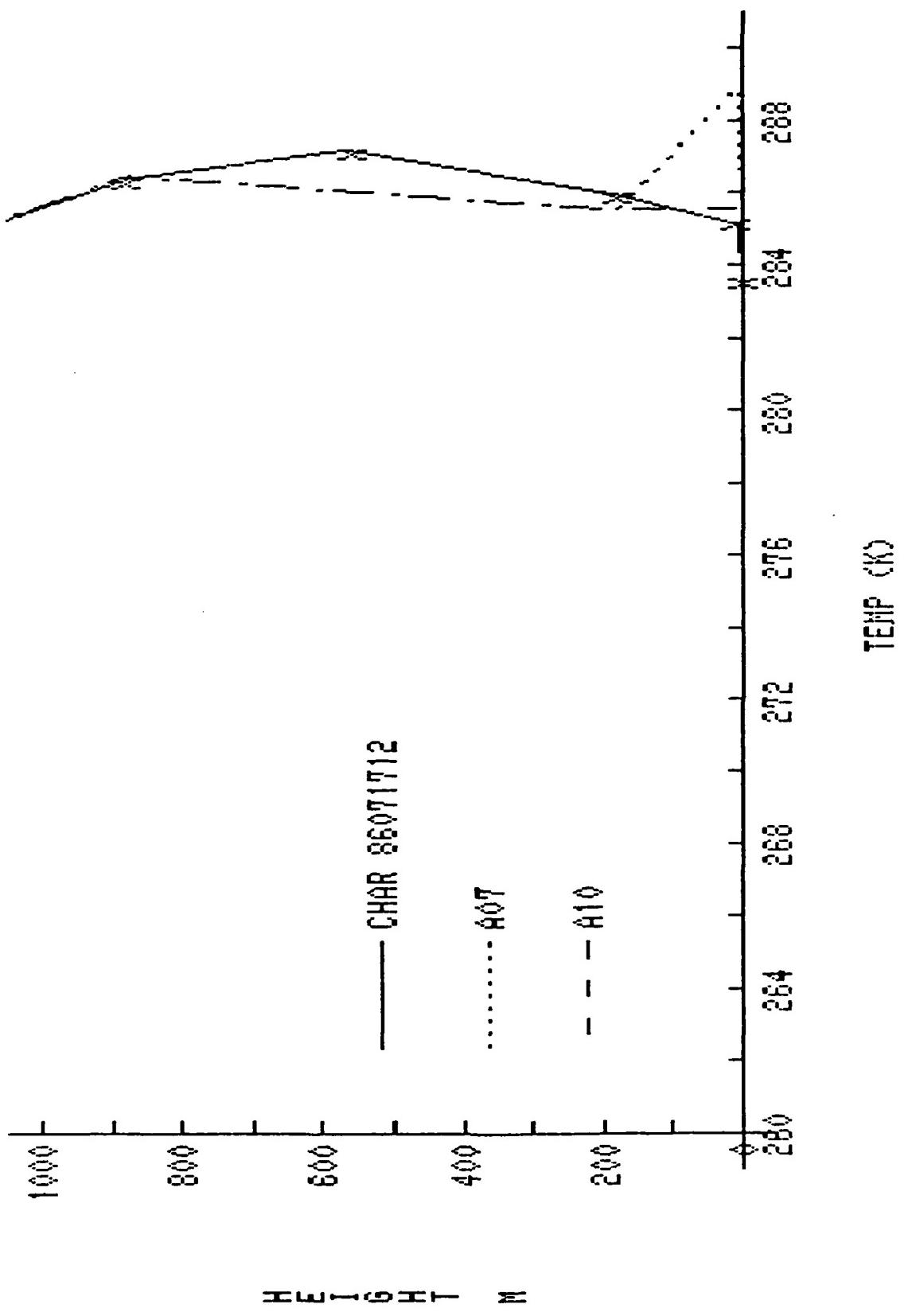
Figure 32. As in Fig. 1, for ship Charlie 12Z 17 July 1986.
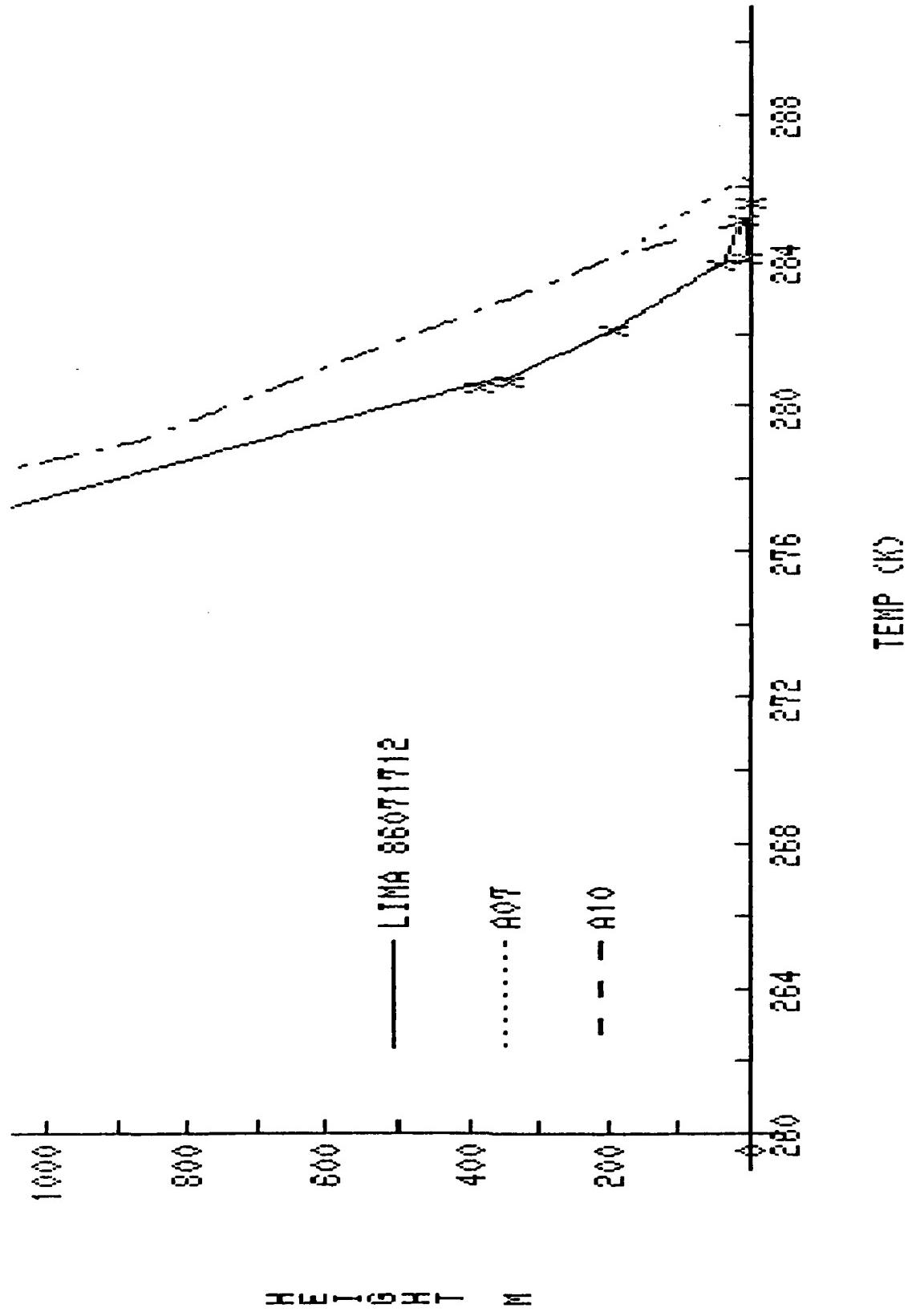
Figure 33. As in Fig. 1, for ship Lima 12Z 17 July 1986.

TEMP (K)

HEIGHT M
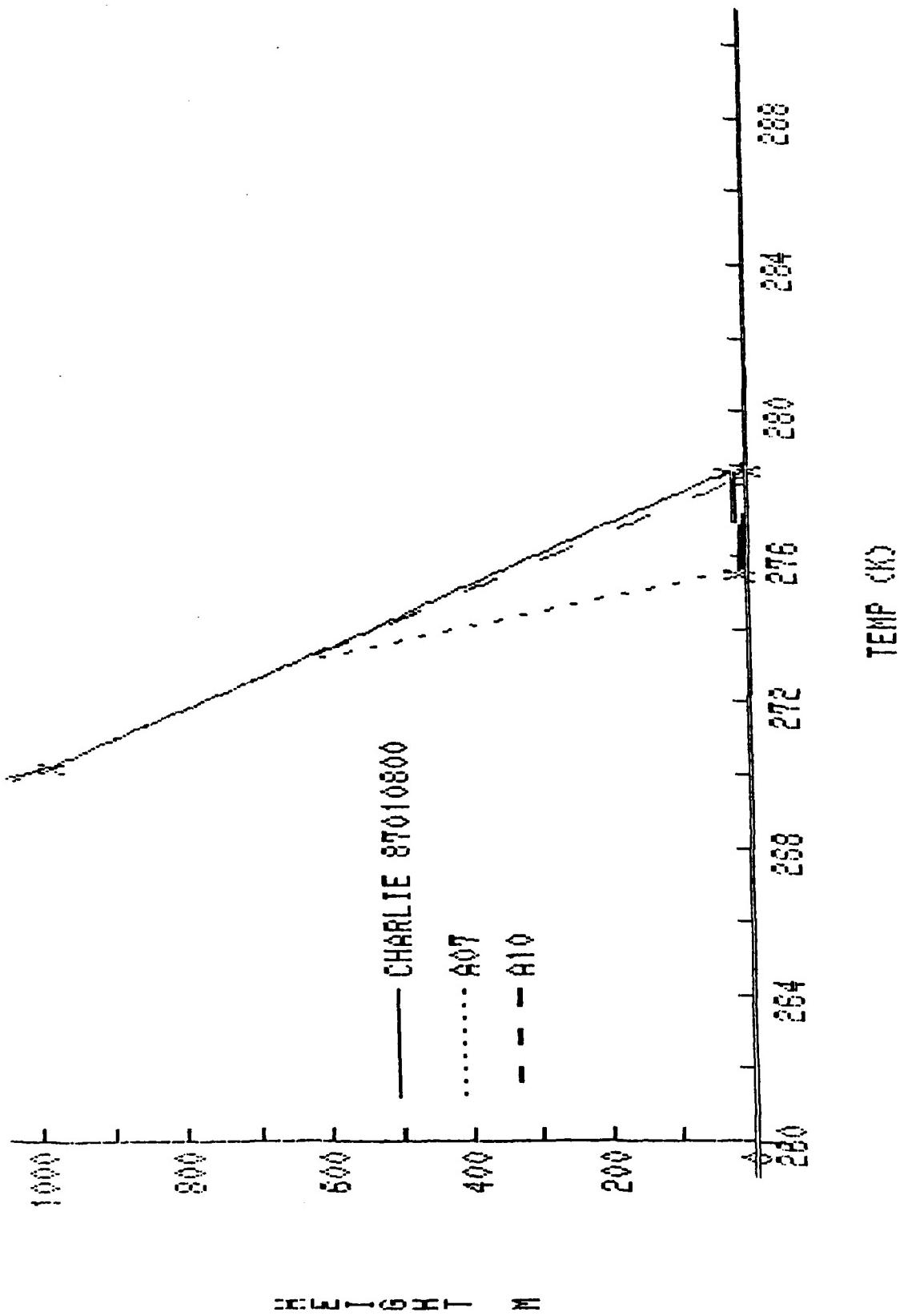
Figure 34. As in Fig. 1, for ship Charlie 00Z 8 January 1987.
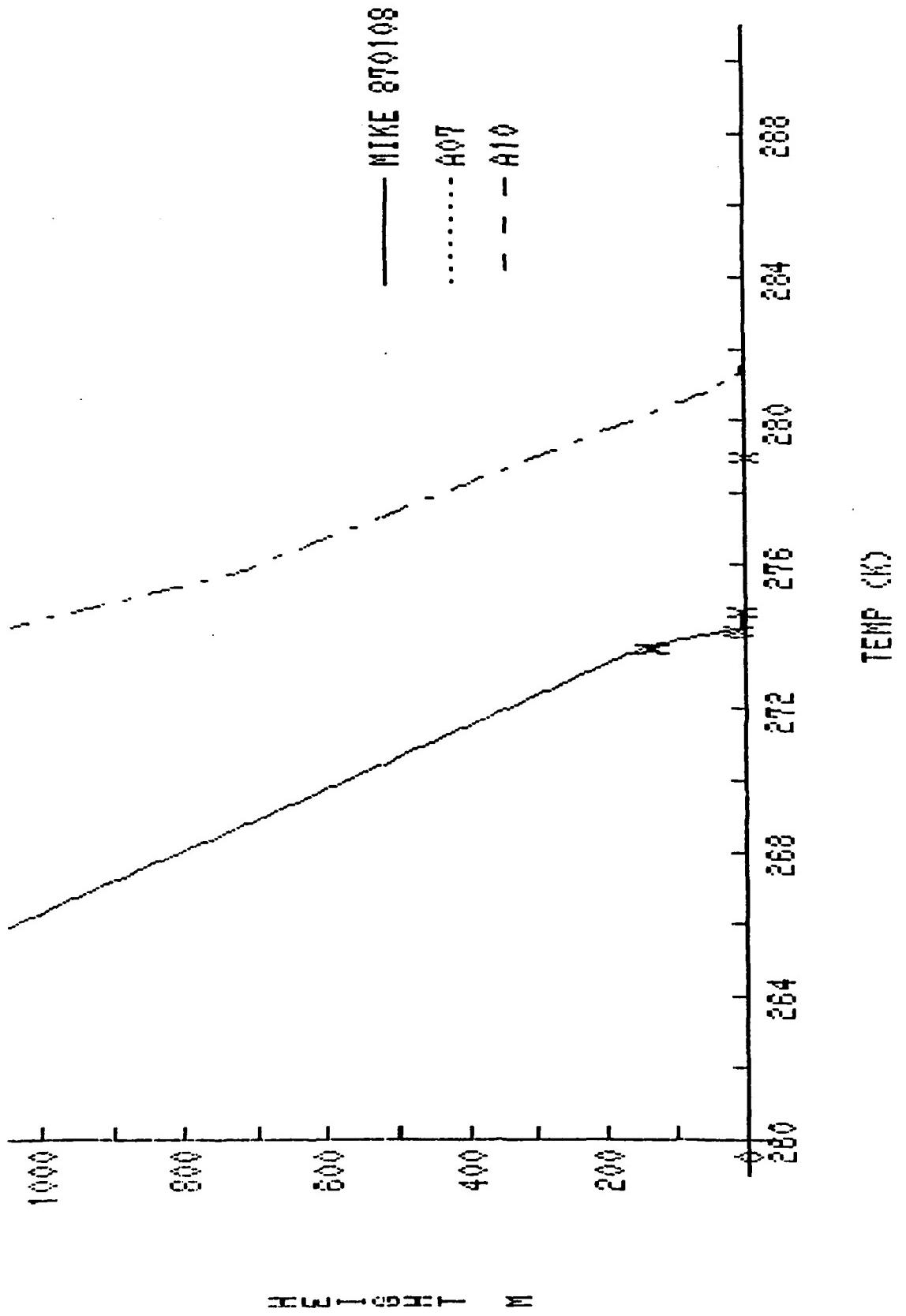
Figure 35. As in Fig. 1, for ship Mike 00Z 8 January 1987.

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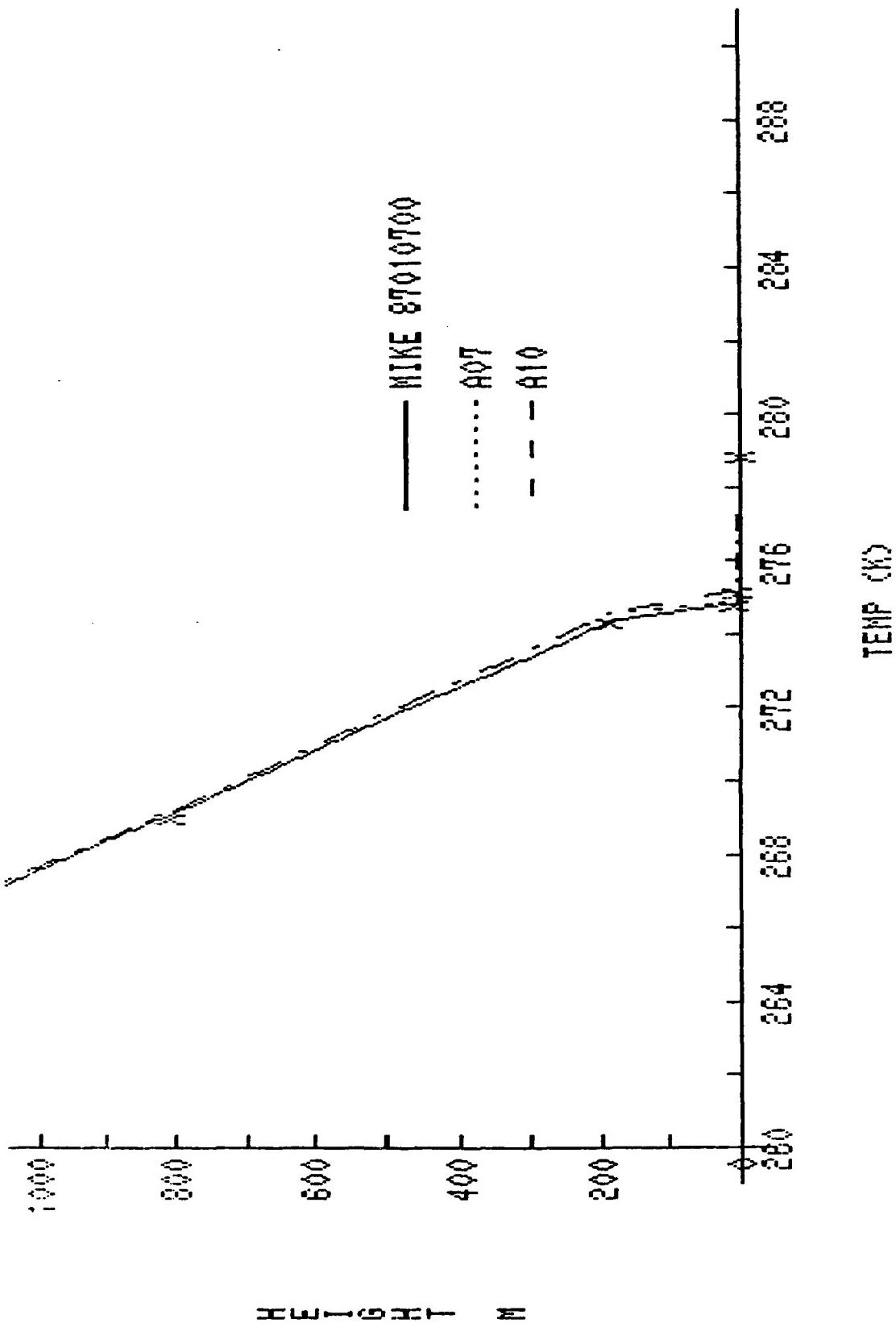
Figure 36. As in Fig. 1, for ship Mike 00Z 7 January 1987.
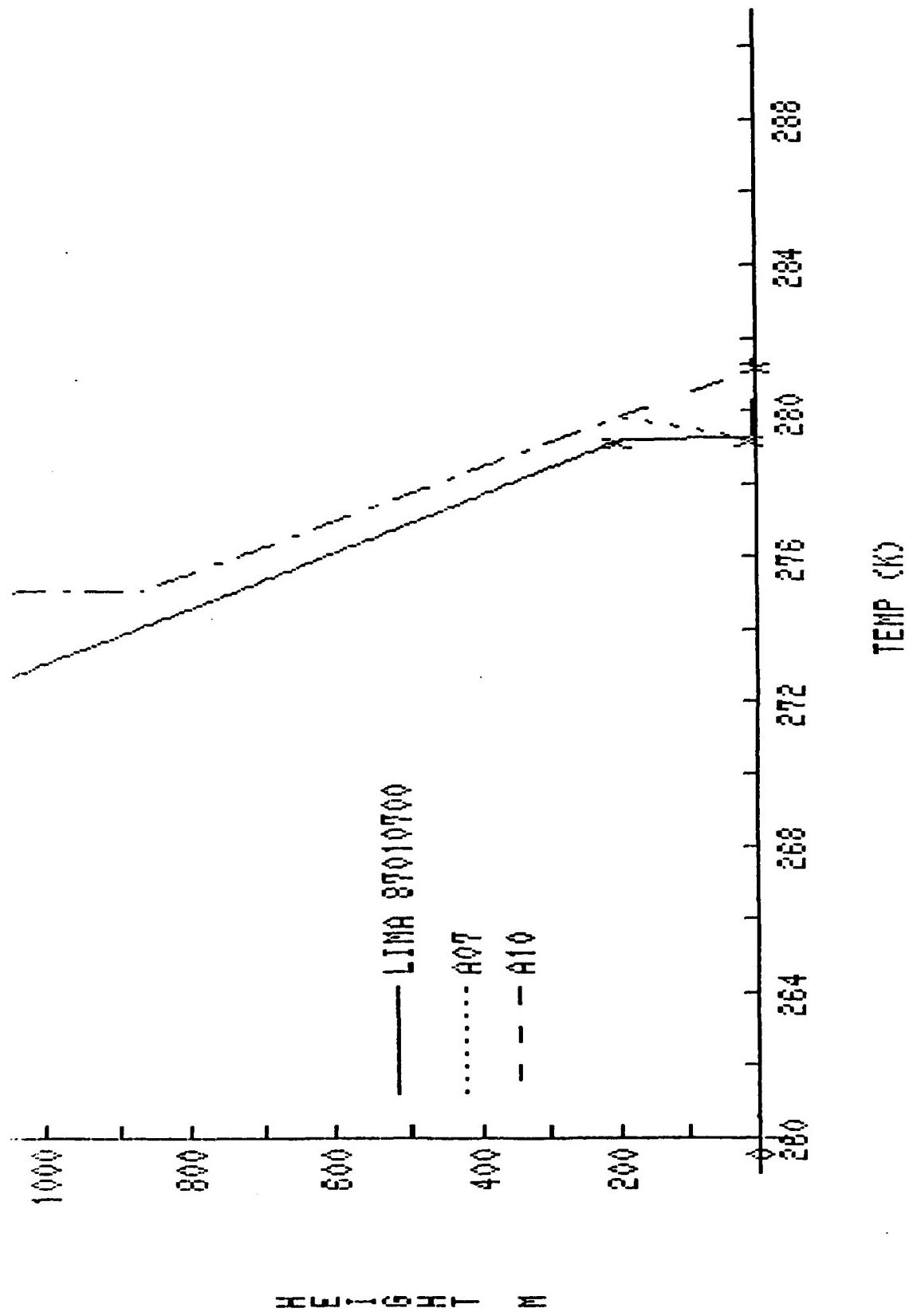
Figure 37. As in Fig. 1, for ship Lima 00Z 7 January 1987.
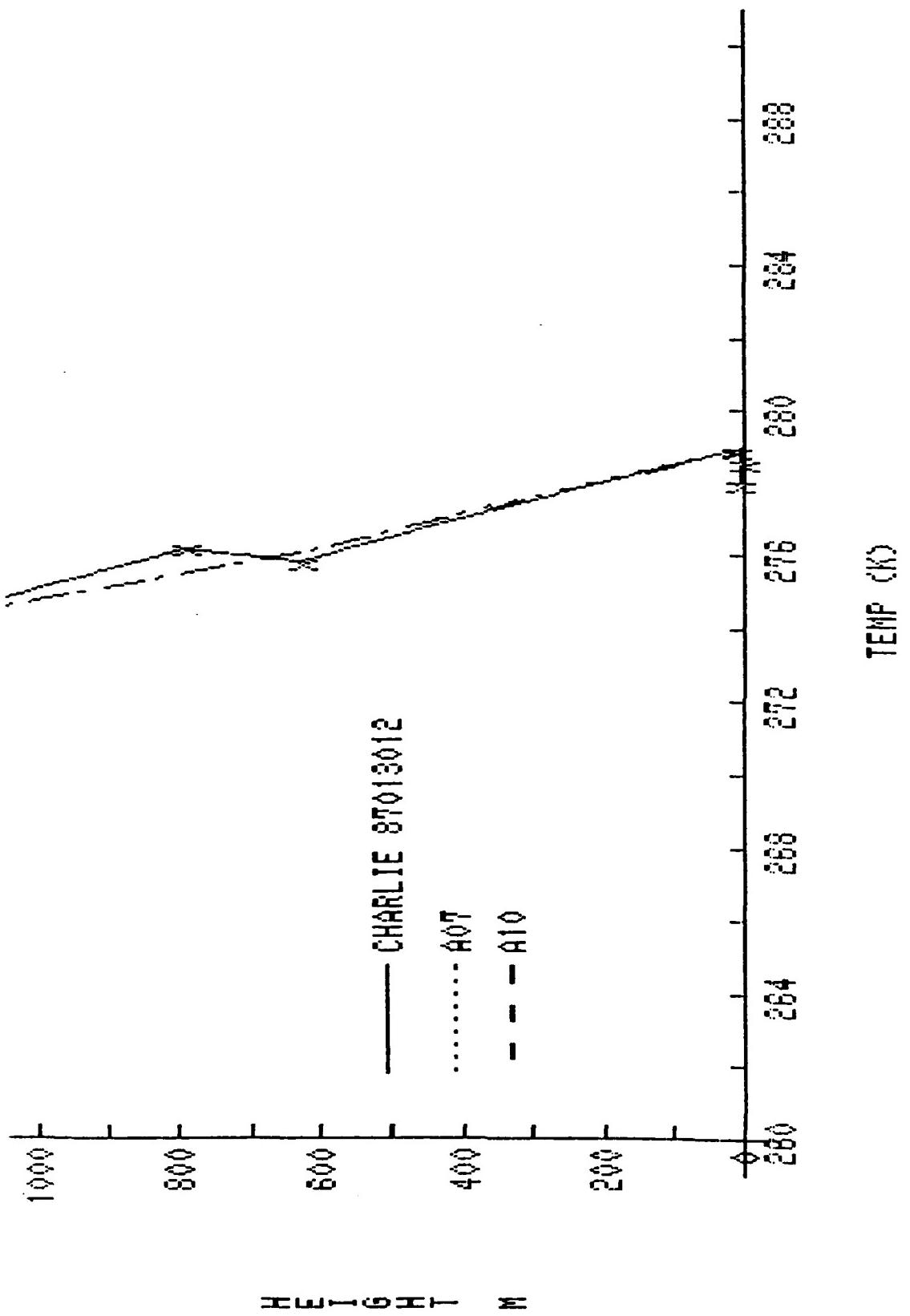
Figure 38. As in Fig. 1, for ship Charlie 12Z 30 January 1987.
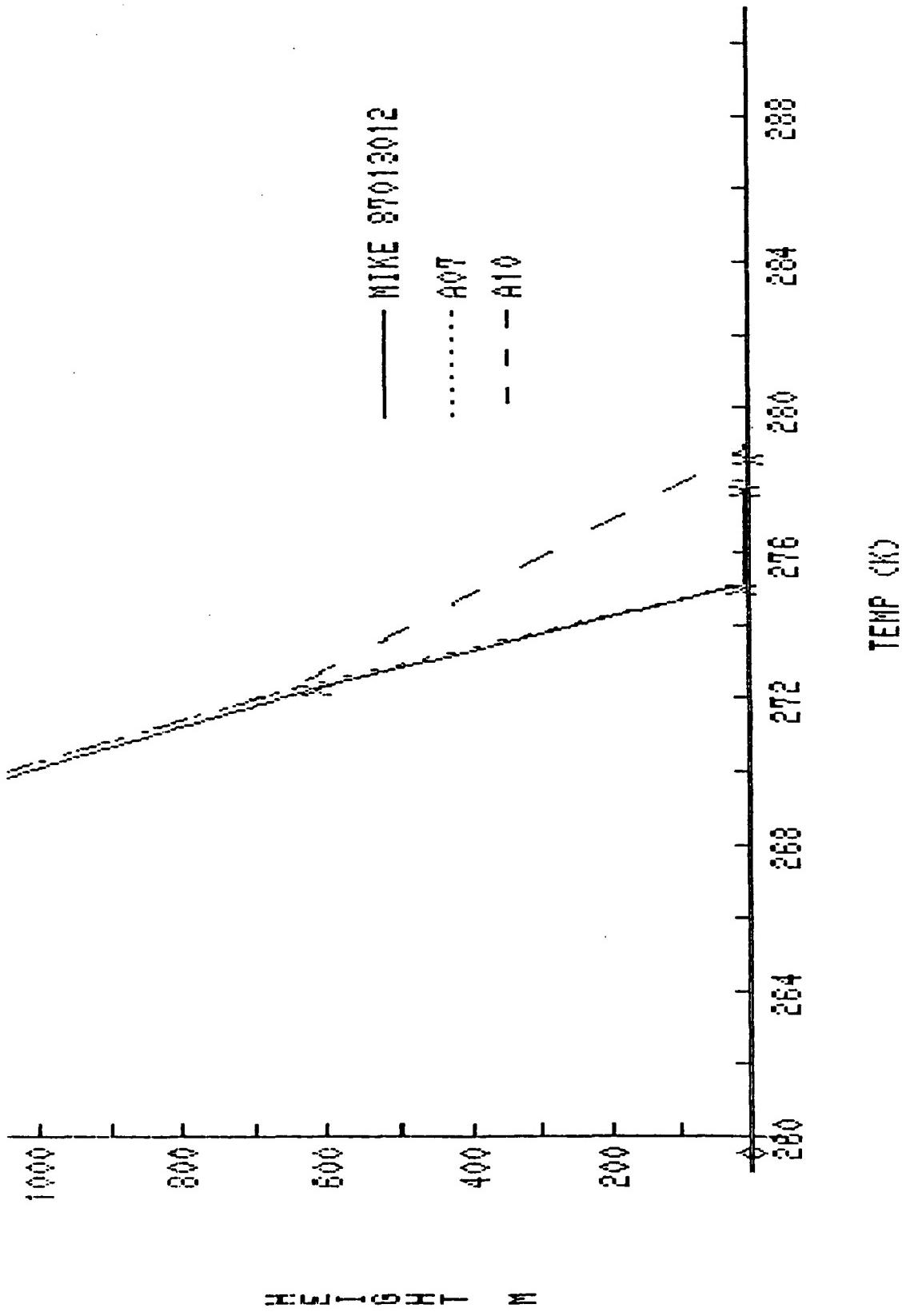
Figure 39.   As in Fig. 1, for ship Mike 12Z 30 January 1987.
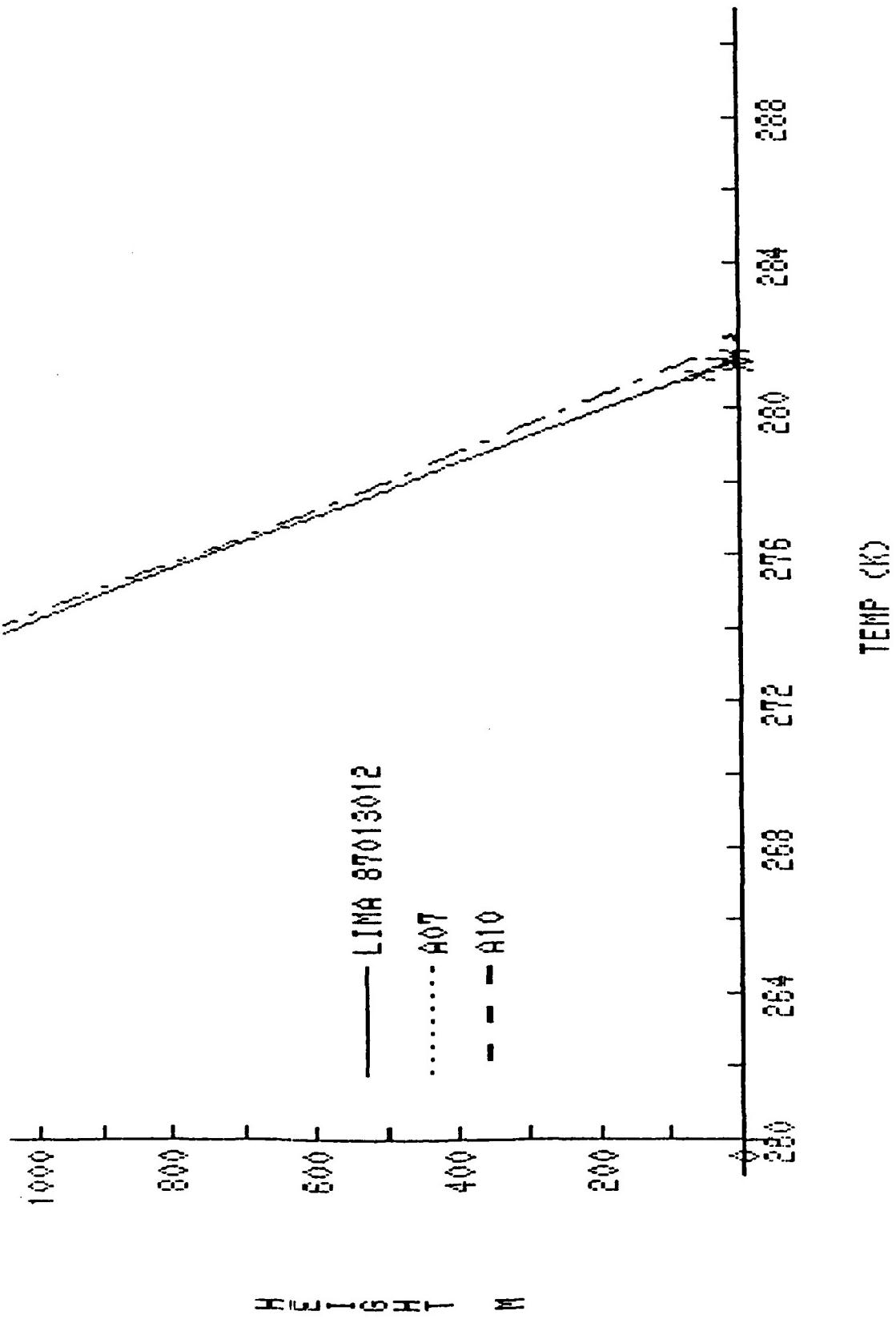
Figure 40. As in Fig. 1, for ship Lima 12Z 30 January 1987.
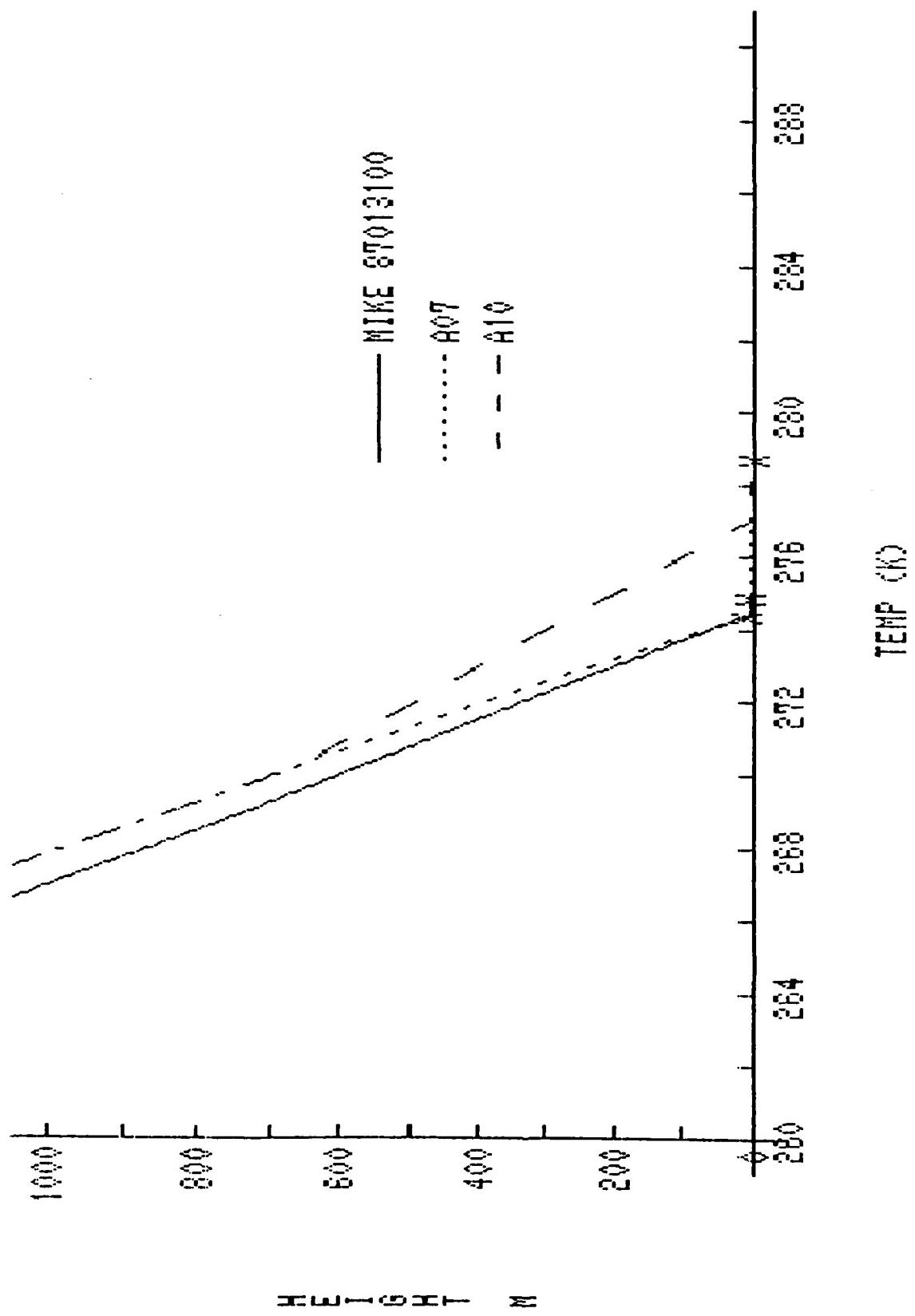
Figure 41. As in Fig. 1, for ship Mike 00Z 31 January 1987.
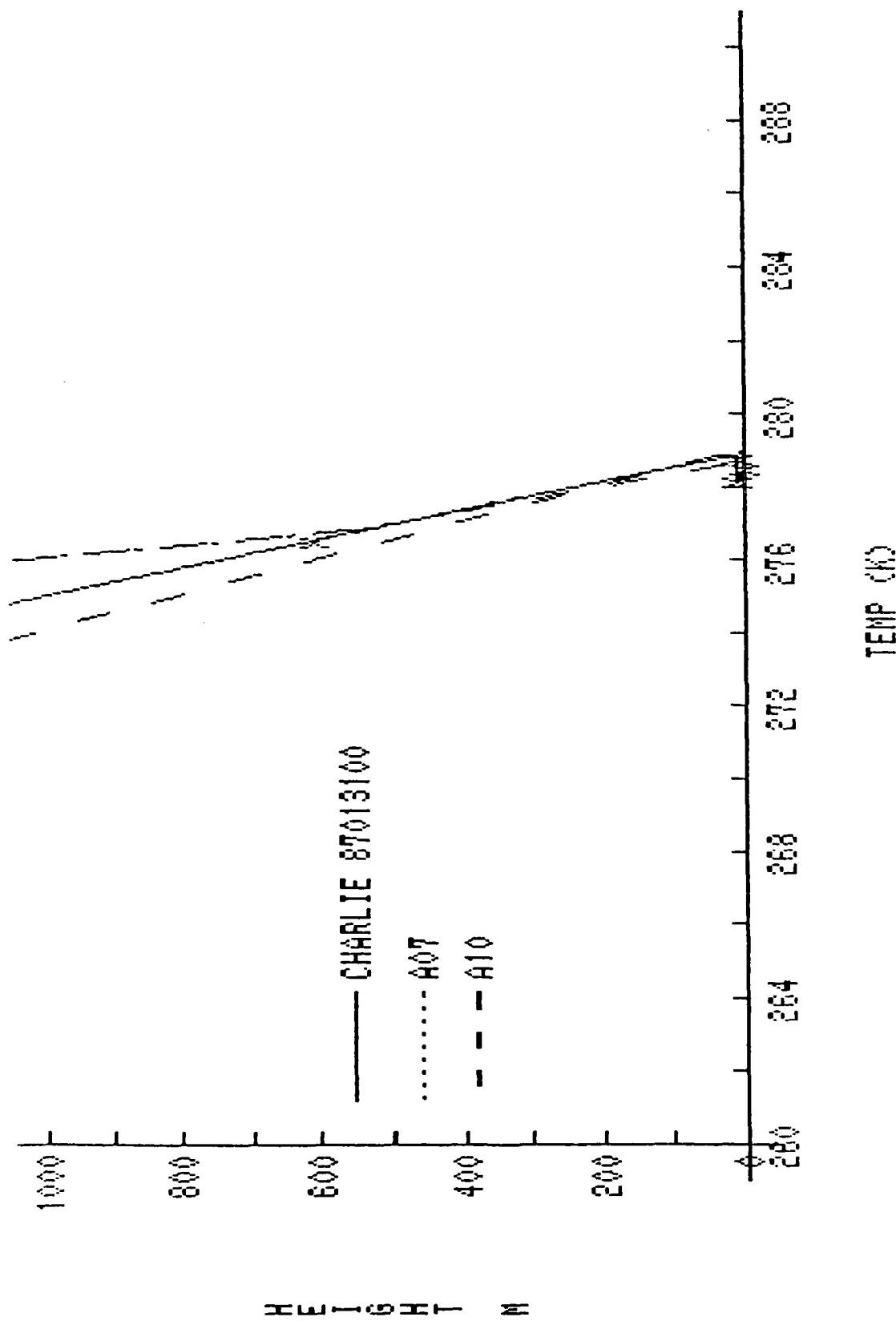
Figure 42. As in Fig. 1, for ship Charlie 00Z 31 January 1987.
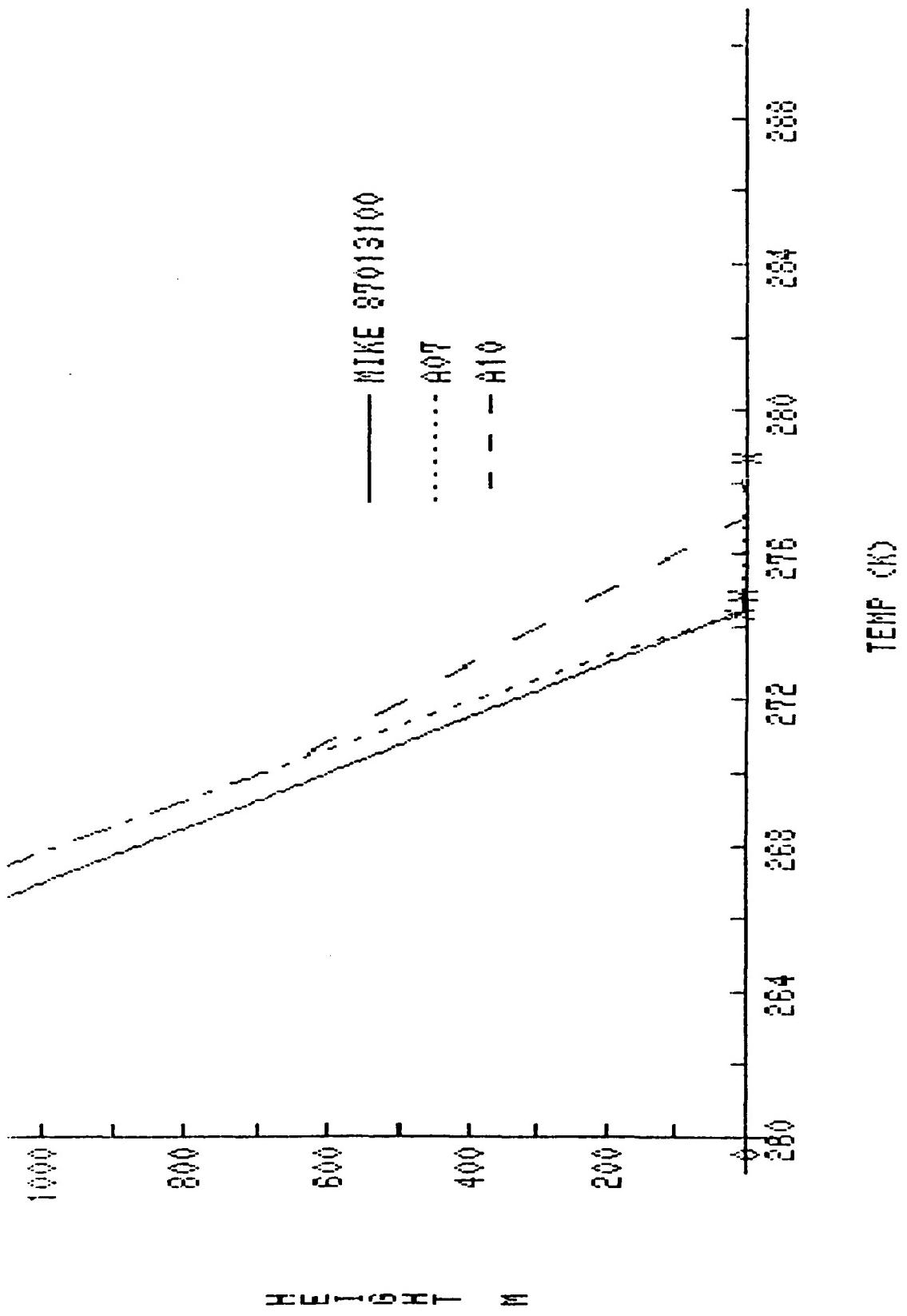
Figure 43. As in Fig. 1, for ship Mike 12Z 31 January 1987.
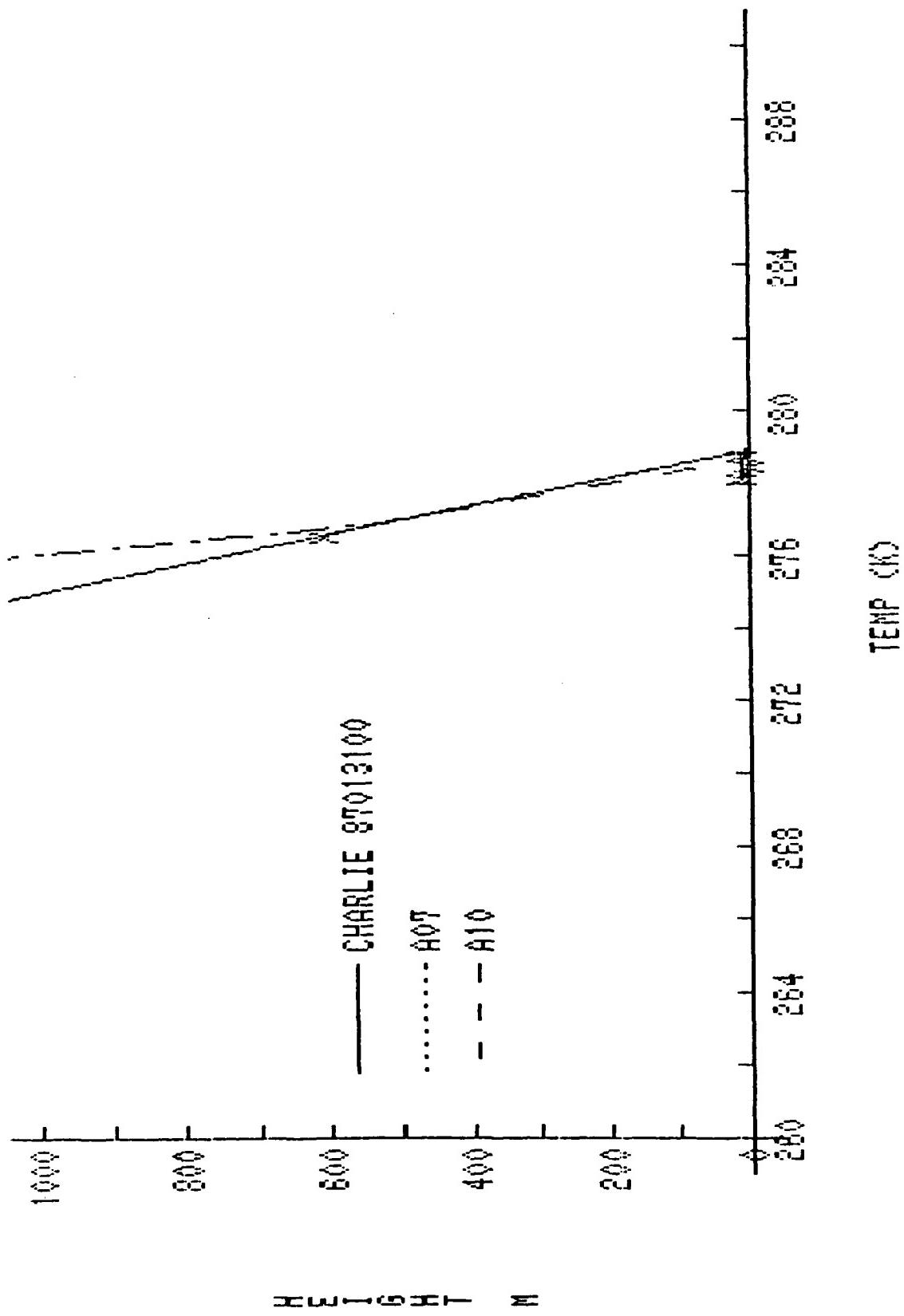
Figure 44. As in Fig. 1, for ship Charlie 12Z 31 January 1987.
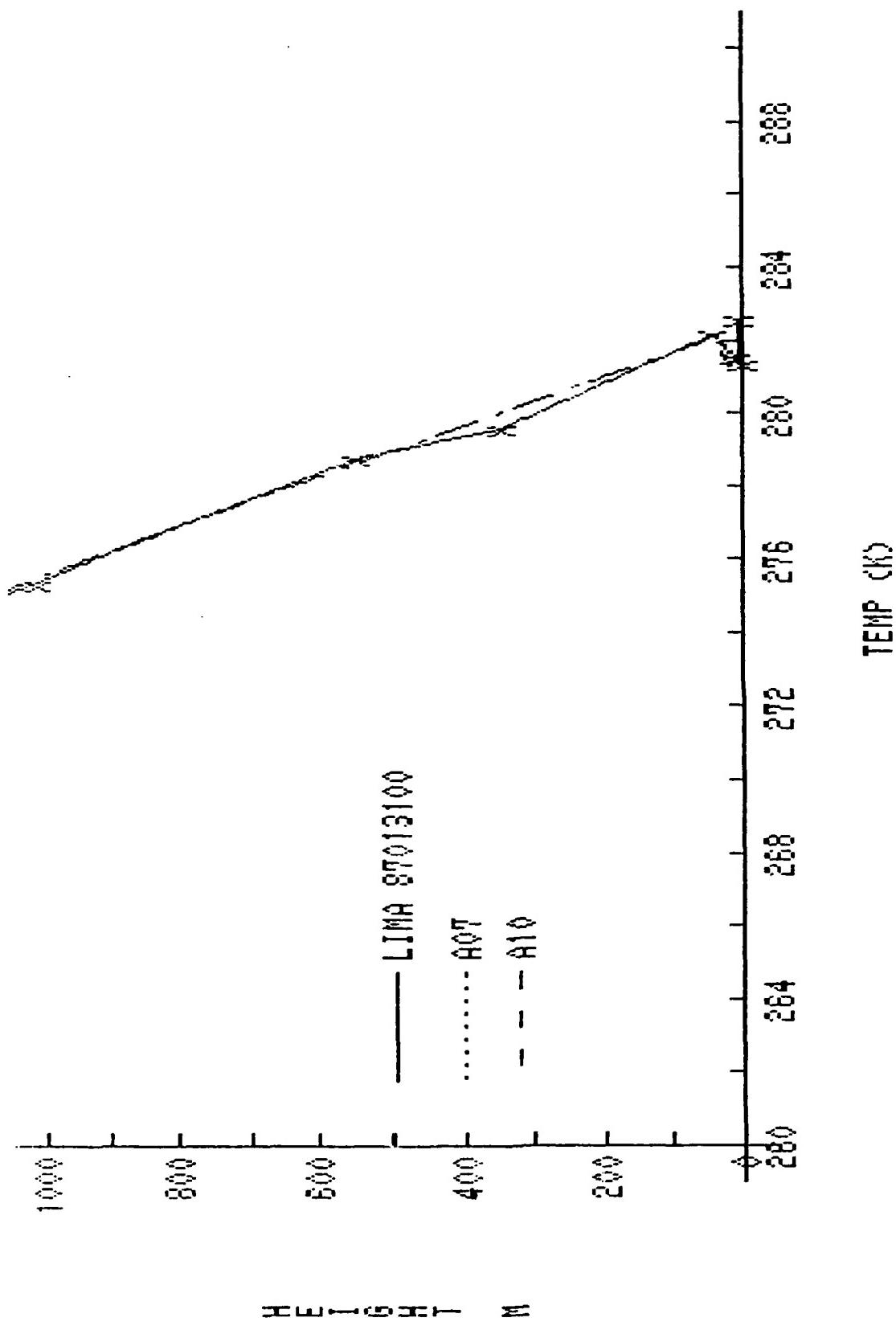
Figure 45. As in Fig. 1, for ship Lima 00Z 31 January 1987.
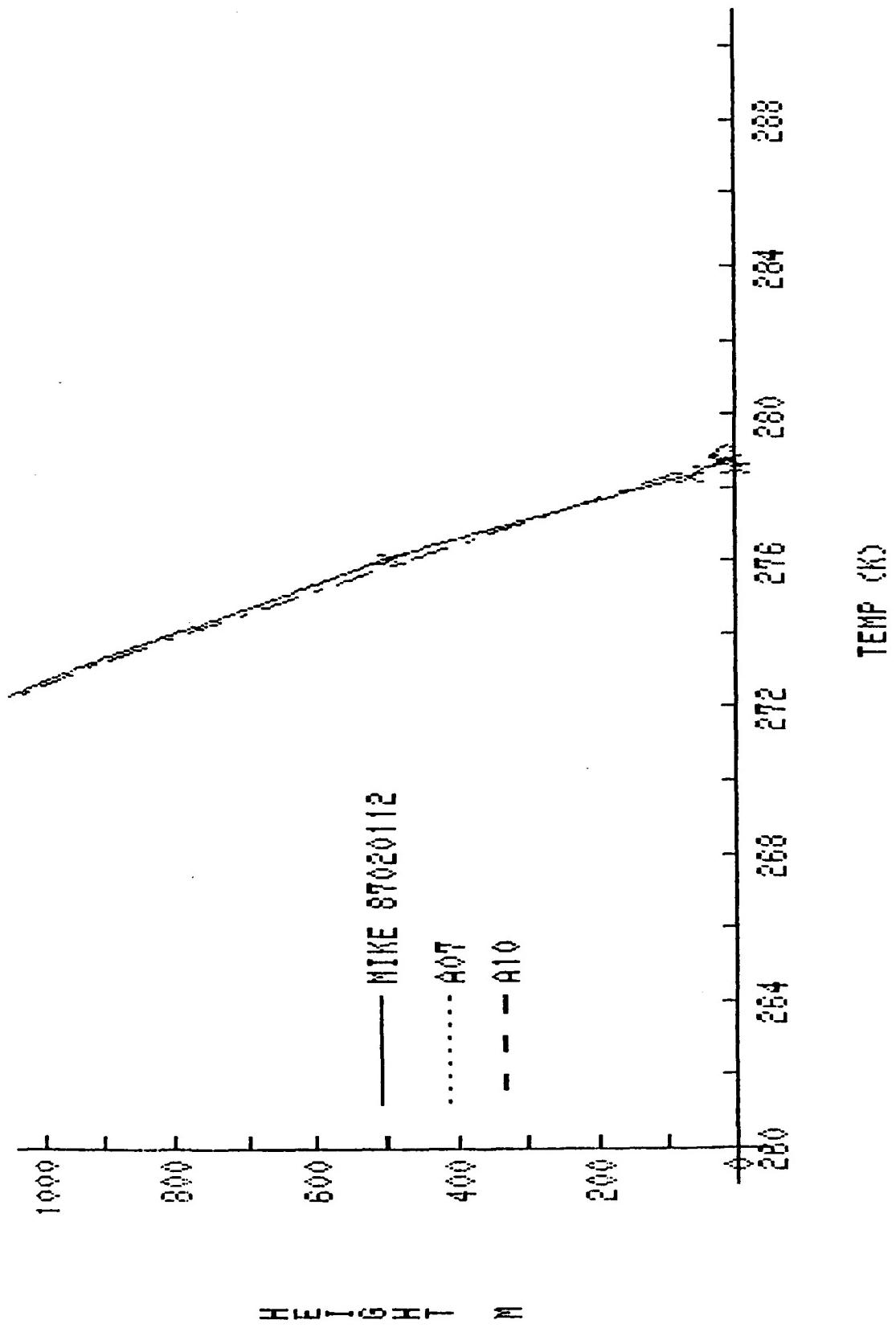
Figure 46. As in Fig. 1, for ship Mike 12Z 1 February 1987.
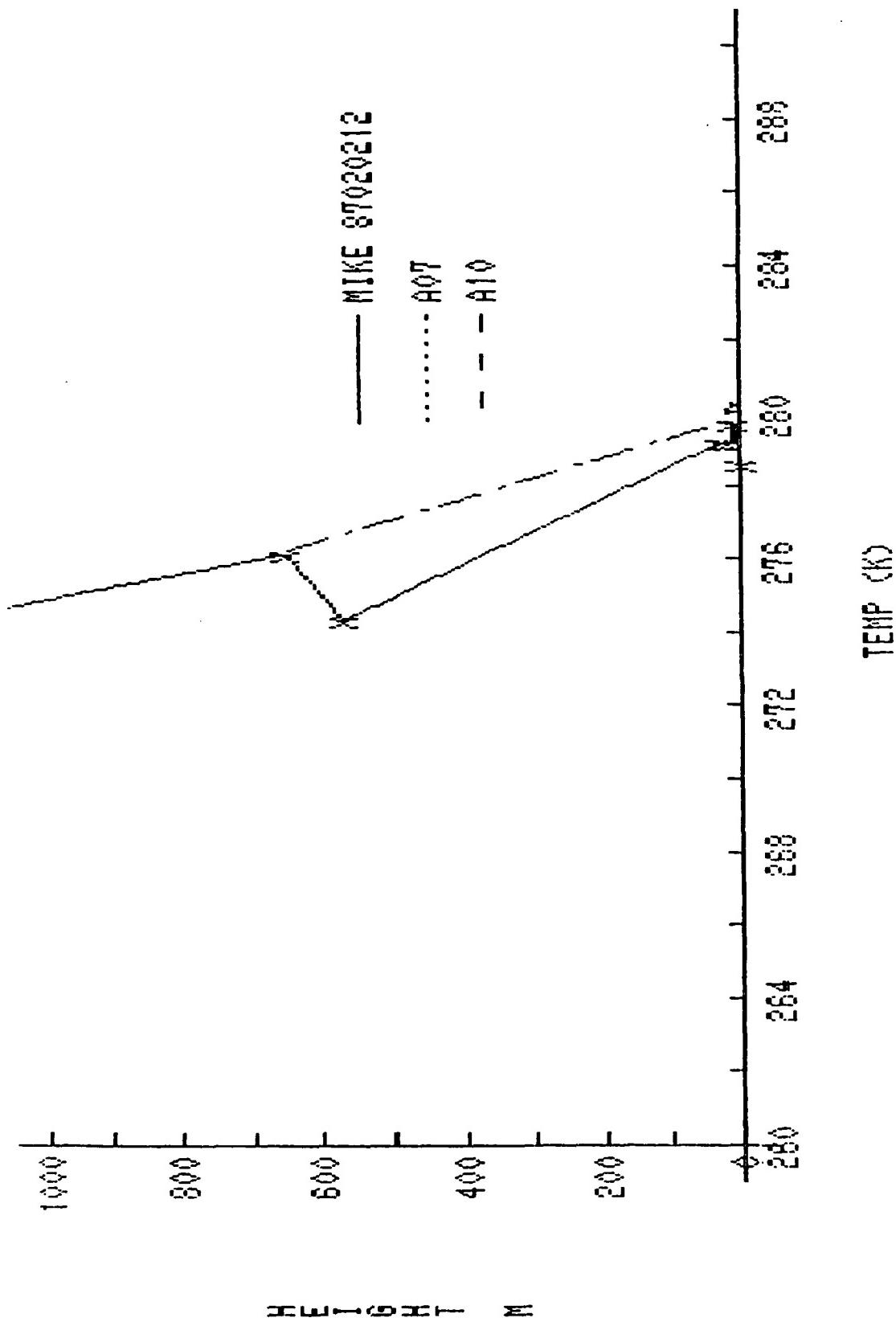
Figure 47. As in Fig. 1, for ship Mike 12Z 2 February 1987.
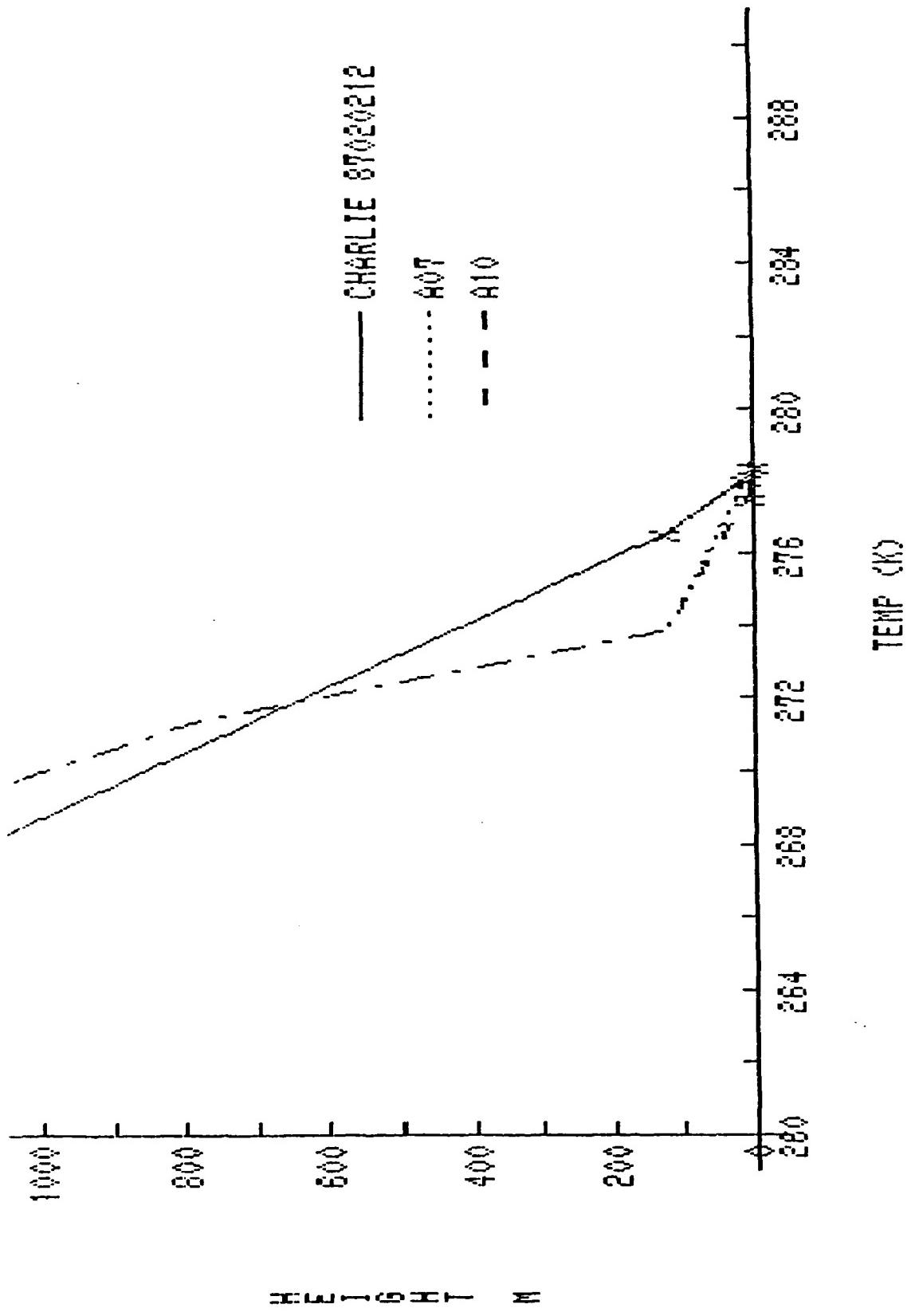
Figure 48. As in Fig. 1, for ship Charlie 12Z 2 February 1987.
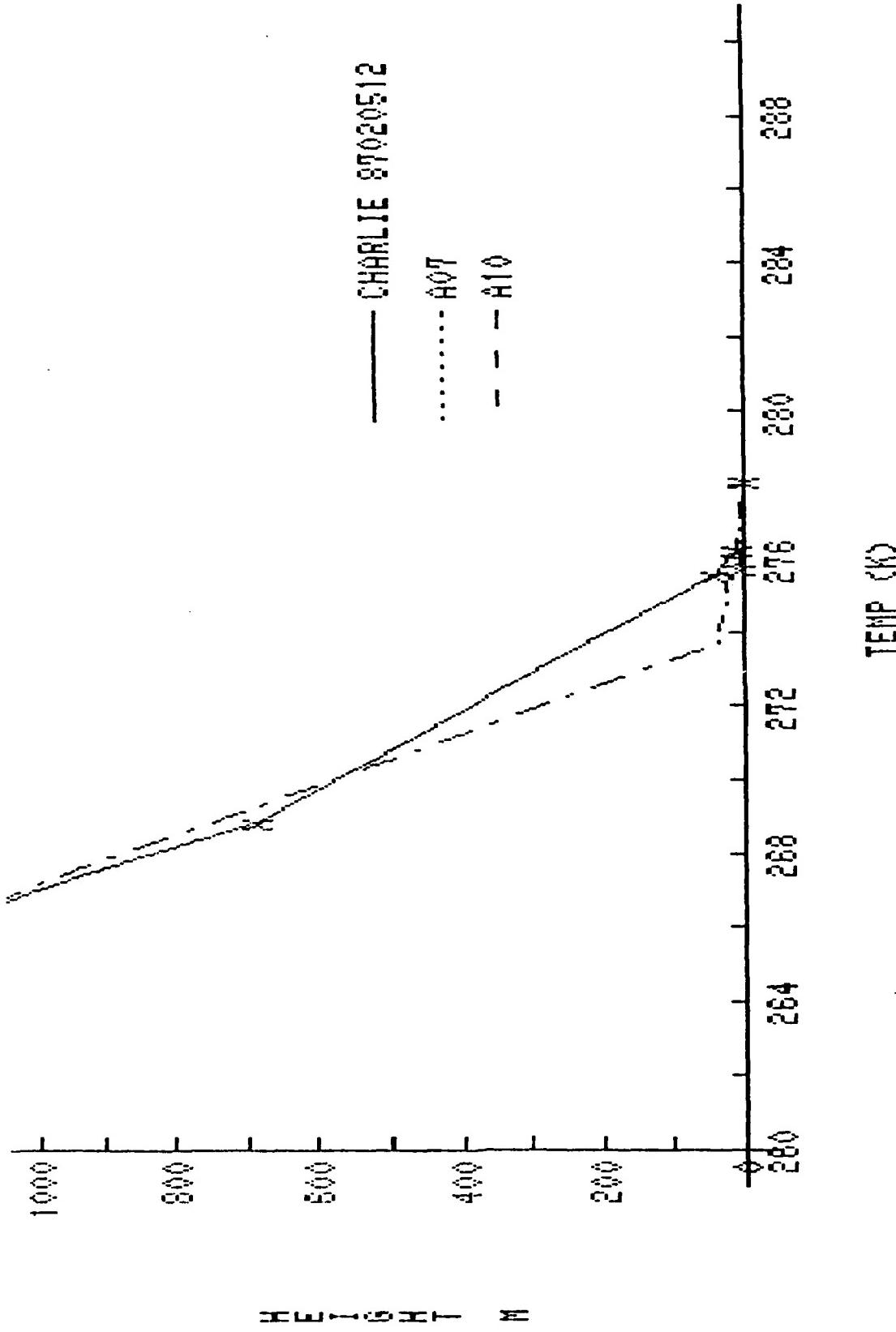
Figure 49. As in Fig. 1, for ship Charlie 12Z 5 February 1987.

MIKE 87020512

A07

A10

TEMP (K)

HEIGHT M

264   268   272   276   280   284   288

280

200   400   600   800   1000
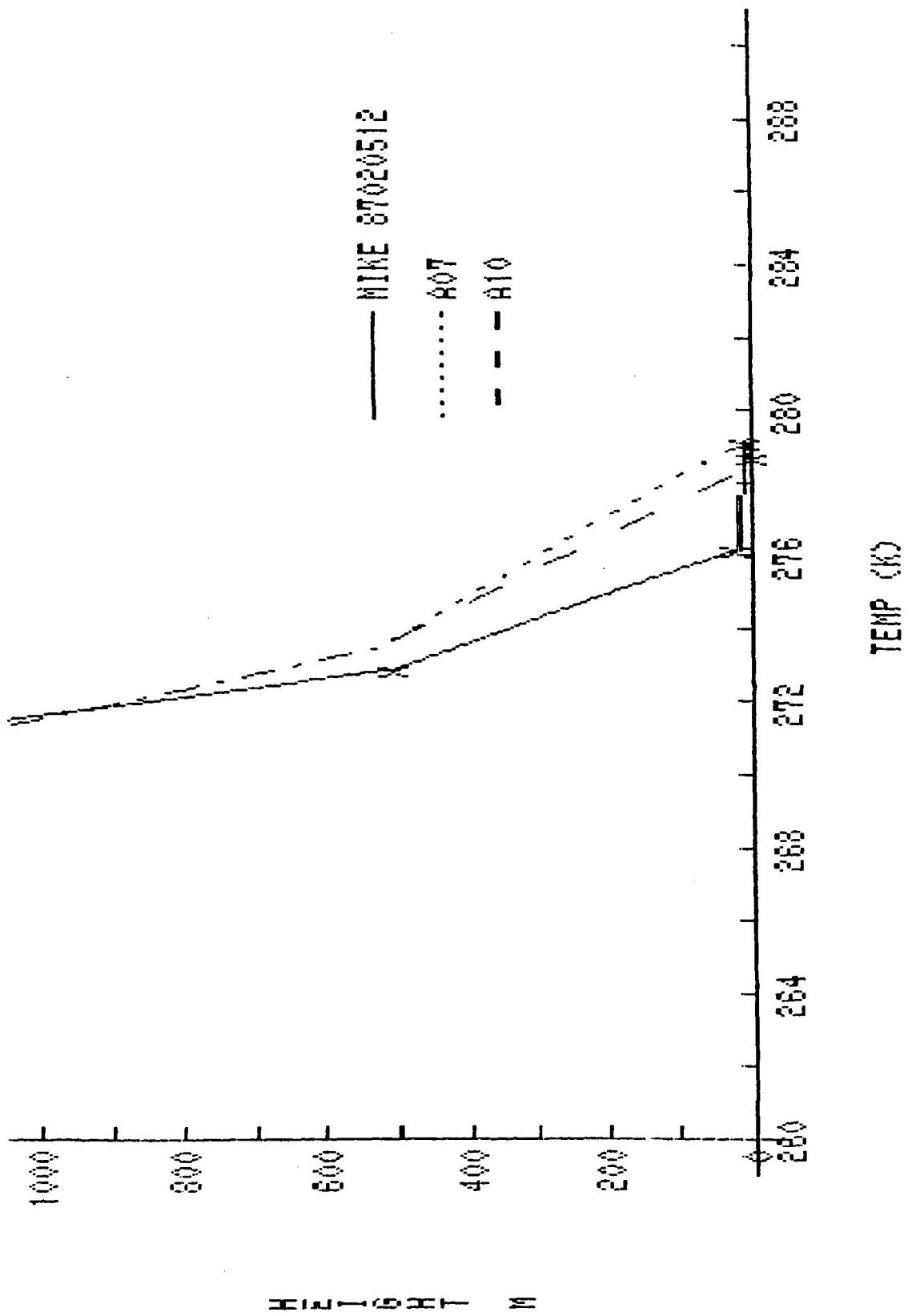
Figure 50.   As in Fig. 1, for ship Mike 12Z 5 February 1987.
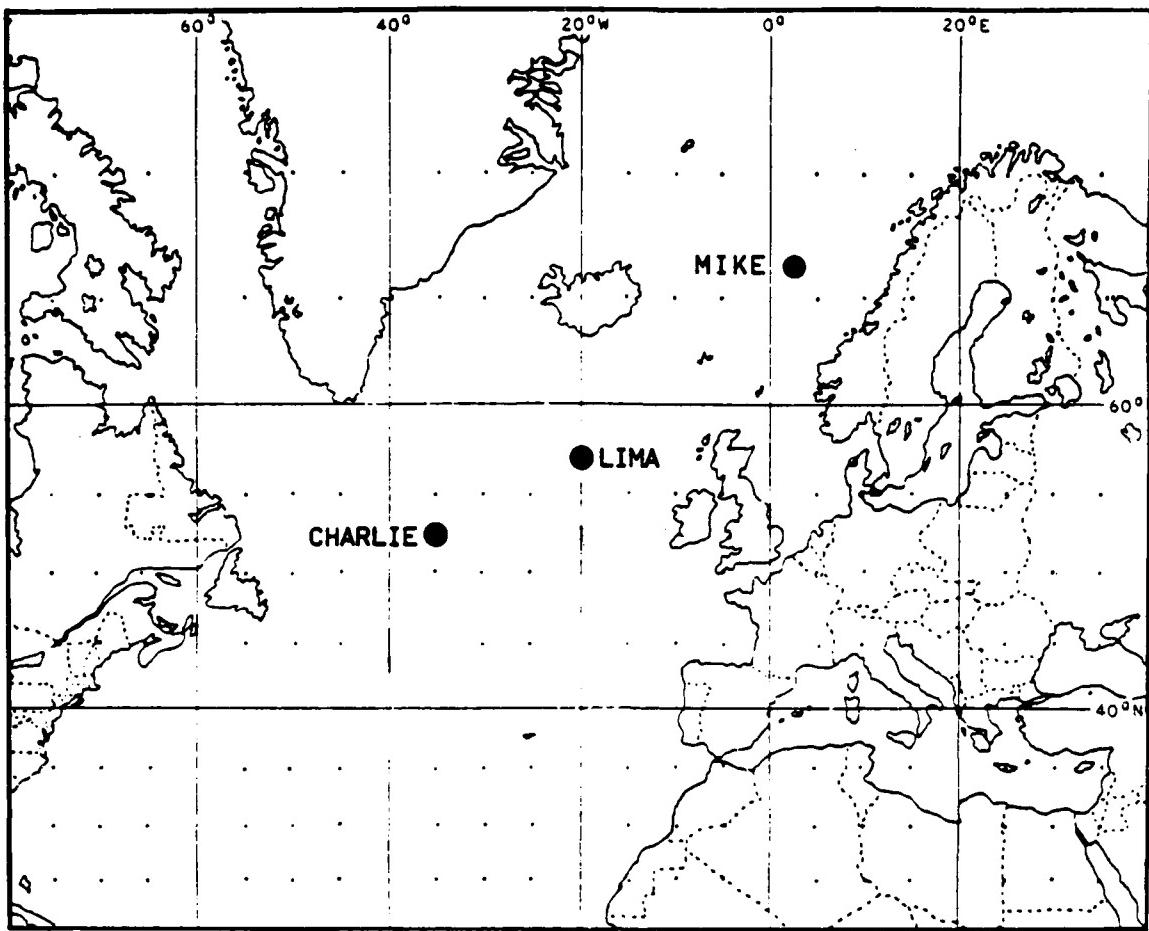
Figure 51. Locations of weather station ships:
Charlie -- 52.7°N, 35.5°W
Mike -- 66.1°N, 1.7°E
Lima -- 56.9°N, 20.4°W

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